ISSN 0704-3716

Canadian Translation of Fisheries and Aquatic Sciences

No. 5271

# A plan for a water protection programme for the sea off Kuivaniemi with reference to fish farming. Working Group Proposal

Working Group

Original title: Kuivaniemen edustan merialueen kalankasvatusta koskeva vesiensuojelusuunnitelma. Tyoryhman ehdotus

In: Vesihallituksen monistesarja 298, 65 pp, 1984

Original language: Finnish

Fisheries & Oceans
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Available from:
Canada Institute for Scientific and Technical Information
National Research Council
Ottawa, Ontario, Canada K1A 0S2

1986

87 typescript pages

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90-02741/

MULTILINGUAL SERVICES DIVISION – DIVISION DES SERVICES MULTILINGUES

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## LIBRARY IDENTIFICATION – FICHE SIGNALÉTIQUE

| Translated from - Traduction de | Into - En |
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Working Group

Title in English or French - Titre anglais ou français

A PLAN FOR A WATER PROTECTION PROGRAMME FOR THE SEA OFF KUIVANIEMI WITH REFERENCE TO FISH FARMING. WORKING GROUP PROPOSAL.

Title in foreign language (Transliterate foreign characters)
Titre en langue étrangère (Transcrire en caractères romains)

KUIVANIEMEN EDUSTAN MERIALUEEN KALANKASVATUSTA KOSKEVA VESIENSUOJELUSUUNNITELMA. TYORYHMAN EHDOTUS.

Reference in foreign language (Name of book or publication) in full, transliterate foreign characters.
Référence en langue étrangère (Nom du livre ou publication), au complet, transcrire en caractères romains.

Vesihallituksen monistesarja

Reference in English or French - Référence en anglais ou français

Mimeograph Series of the National Water Administration

| Publisher - Éditeur | DATE OF PUBLICATION / DATE DE PUBLICATION | | | Page Numbers in original / Numéros des pages dans l'original |
|---|---|---|---|---|
| (Government of Finland) | Year / Année | Volume | Issue No. / Numéro | 65 pages |
| Place of Publication / Lieu de publication | | | | Number of typed pages / Nombre de pages dactylographiées |
| (Finland) | 1984 | - | 298 | 1-86 |

Requesting Department / Ministère-Client: Fisheries and Oceans

Translation Bureau No. / Notre dossier nº: 2909905

Branch or Division / Direction ou Division: IPB Nanaimo, BC

Translator (Initials) / Traducteur (Initiales): OM

Person requesting / Demandé par: J. Morrison

Your Number / Votre dossier nº: -

Date of Request / Date de la demande: 86-09-16

Canada

SEC 5-111 (84-10)

Secretary of State / Secrétariat d'État

MULTILINGUAL SERVICES DIVISION – DIVISION DES SERVICES MULTILINGUES

TRANSLATION BUREAU / BUREAU DES TRADUCTIONS

| Client's No.–Nº du client | Department – Ministère | Division/Branch – Division/Direction | City – Ville |
|---|---|---|---|
| - | Fisheries and Oceans | IPB | Nanaimo, BC |
| **Bureau No.–Nº du bureau** | **Language – Langue** | **Translator (Initials) – Traducteur (Initials)** | |
| 2909905 | Finnish | OM | NOV 2 |

Vesihallituksen monistesarja (Mimeograph Series of the National Water Administration), No. 298, pp. 1-65, 1984, Helsinki, (Finland)
ISBN 951-46-8385-4
ISSN 0358-7169

# A PLAN FOR A WATER PROTECTION PROGRAMME FOR THE SEA OFF KUIVANIEMI WITH REFERENCE TO FISH FARMING. WORKING GROUP PROPOSAL

The writers are responsible for the contents of the publication and it cannot be referred to as an official policy of the National Water Administration.

The publication can be obtained from the Water Division of the Water District of Oulu.

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# F O R E W O R D

5*

The planning of a water protection programme for the marine area off Kuivaniemi with reference to fish farming was launched on the initiative of the Water Division of the Water District of Oulu in May 1982. To carry out the planning, the Water Division formed a working group with the following composition: senior engineer Mauno Ronkkomaki (chairman), senior inspector Urpo Myllymaa and licenciate Pekka Hynninen (in charge). Limnologist Into Kekkonen participated in the planning as a liaison of the National Water Administration. After Mr. Kekkonen moved to the Ministry of Environment, the liaison was advisor Seija Salonen. The planner was engineering undergraduate Reino Kurkela. A tentative report by the working group was finished in June 1983. It was largely identical in content to Kurkela's dissertation "Conditions for Fish Farming in the Sea off Kuivaniemi" (Kurkela 1983).

The municipality of Kuivaniemi and the following communities and authorities were asked to comment on the tentative proposal of the working group: Kuivaniemi Allotment Area, Fishery Association of Kuivaniemi, Regional Planning Authority of Ostrobothnia, Finnish Association of Salmon Culturists, Environmental District of Ostrobothnia, Game and Fishing Research Institute, Federation of Gulf of Bothnia Fishermen, County Administration of Oulu, Central Bureau of the Fishing District of Oulu, Water Protection Association of Oulu, Oulu Farming Centre, Marine Research Institute, Gulf of Bothnia Research Station of the University of Oulu, and Water Division of the Water District of Lapland. On the basis of the comments and the feedback received from the National Water Administration, the working group revised the tentative proposal into its final form. Biologist Kari Kainua acted as the planner at this stage.

*Numbers in the right-hand margin indicate the corresponding page numbers in the original. Translator's note.

# 1 INTRODUCTION 7

The volume of rainbow trout culture increased sharply in marine areas in Finland at the end of the 1970s. The sharp increase in marine culture was encouraged by factors such as lower investment costs associated with net cages and a faster growth rate of the fish. According to the statistics of the Game and Fishing Research Institute, a total of 293 facilities, of which 98 in marine areas, participated in food fish production in Finland in 1982. A total of 3,226 tonnes of rainbow trout was produced in marine areas. Just over one half of this amount, or 2,000 tonnes, was cultured in the Turku archipelago (Water Division of the Water District of Turku). In 1983, six facilities with a combined production of 345 t/a were operating in the planning area. In addition to the current culture, the Water District of Oulu has learned of plans to increase production in the planning area to about 2,170 tonnes a year. Kuivaniemi is joining the Turku archipelago as a centre of marine fish farming.

The operations may cause conflicts with recreational use, coastal housing, fishing, and conservation of some islands. A plan to control water pollution in the area was thought to be necessary to coordinate the increasing fish farming and other uses of the water system. During the planning, the planners familiarized themselves with fish farming in the area, maintained contact with fish farmers already in operation or planning to operate, negotiated with fishermen and the Fishery Association, listened to the opinions of landowners and the coastal population, and maintained contact with the Municipality of Kuivaniemi and different offices and establishments.

The plan chiefly concentrated on the state of the water system, its usability, actual use and the impact of fouling on these. The objectives of the plan are:

- to look into pollution in the area, its development and contributing factors.
- to look into possibilities to reduce pollution caused by existing fish farming.
- to look into possibilities to increase fish farming in the area.

Individuals such as fish farmers and owners of the marine area may take advantage of the plan. The plan serves as a guide to the National Water Administration when it issues statements on licence applications to the Water Rights Court and preliminary statements to those planning fish farming, and when it enforces the Water Rights Act and licencing decisions. The plan also helps inspections as well as the work of municipal water, health and building boards. It is the duty of water authorities to ensure that the recommendations are implemented and to inform the parties concerned as may be necessary.

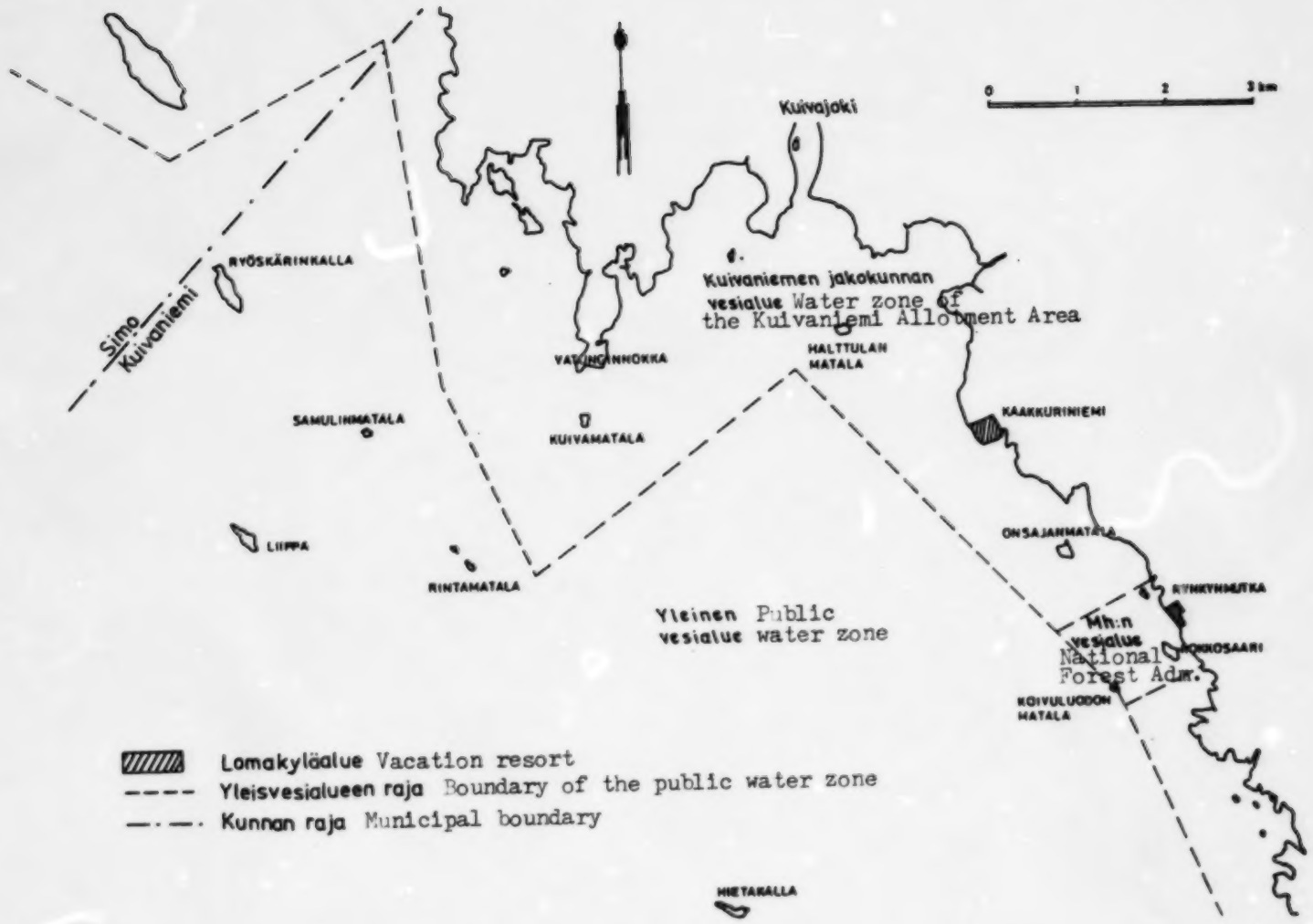
# 2 PLANNING AREA

## 2.1 GENERAL DESCRIPTION

The planning area (FIG. 1) is situated in the sea off Kuivaniemi in the northeastern part of the Gulf of Bothnia about 70 km north of Oulu. The plan limits itself to the area off the Municipality of Kuivaniemi. The planning area extends to about 8 km from the shore toward the open sea. The surface area is about 140 $km^2$ and the water volume 0.9 $km^3$. The average depth in the area is 6.2 m. To the south, the impact of fish farming is estimated to extend to the Petajaluoto island area. In the open sea, water current conditions are better and the impact of fish farming extends to about 8 km from the shore.

The coastal area of Kuivaniemi is characterized by barren moraines, sands and bedrock areas jutting to the shore. The sea off Kuivaniemi is part of a shallow inland sea area whose self-cleaning ability is poor. The shallow coastal area extends about 20 km from the shore toward the open sea. Close to the shore, there are several shoals reaching to the surface or close to it, and there are no actual deep places in the area. There are large islands to the north, off Simojoki, only.

The ownership conditions of the planning area are shown in Illustration 1. The most important municipal areas are Vatunginnokka and Kaakkuriniemi. The landward side from the boundary of the public zone is part of the Kuivaniemi Allotment Area and the seaward side is public. The National Forest Administration owns about 100 ha near the Koivuluoto shallow. Islands within public zones are owned by the state and they are managed by the National Water Administration.




**Kuva 1. Kuivaniemen edustan suunnittelualue ja sen omistussuhteet.**
~~Illustration~~ Figure 1. The planning area off Kuivaniemi and its ownership conditions.

## 2.2 POPULATION AND THE ECONOMY



The population of Kuivaniemi totalled 2,504 in 1982 (Municipality of Kuivaniemi 1983). The population of the municipality decreased steadily until 1980, after which the trend was halted and the population is now slightly increasing. Table 1 shows the population of Kuivaniemi in 1982 and a prediction for 1990.

Table 1. The population of Kuivaniemi and changes in it during the planning period (Municipality of Kuivaniemi 1983).

**Taulukko 1. Kuivaniemen väestö ja sen muutokset suunnitelmakaudella (Kuivaniemen kunta 1983).**

| | 1982 | 1983 | 1986 | 1988 | 1990 | |
|---|---|---|---|---|---|---|
| Kokonaisväestö | 2 504 | 2 517 | 2 610 | 2 650 | 2 690 | Total popul. |
| Ammatissa toimivat | 901 | 921 | 983 | 999 | 1 020 | Gainfully employed |
| 0 - 14 vuotiaat | 553 | 497 | 510 | 520 | 540 | 0-14 of age |
| 15 - 64 " | 1 625 | 1 694 | 1 762 | 1 751 | 1 760 | 15-64 of age |
| yli 64 " | 326 | 326 | 338 | 379 | 390 | over 64 |

In 1982, Kuivaniemi had 760 jobs, of which 350 in primary production, 70 in industry, 35 in construction, 150 in services and 120 in trade and traffic. Self-sufficiency in jobs was 85%.

Fish farming has great importance to the economy of Kuivaniemi. The annual monetary value of the current rainbow trout production is about 7-8 million marks. A fish processing plant that processes both wild and cultured fish has been constructed in Vatunginnokka. Fish farms are estimated to need one year-round employee for a production of 20 t/a of fish in inland areas. Because of the amounts of feed and the emptying of cages, manpower needs are 3 to 8 employees towards the end of the summer. However, manpower needs do not increase in a straightforward

fashion within a given facility. During the inspection of Lapplax Ltd., inspectors estimated its job creation as follows:

| Production | Jobs |
|---|---|
| 300 t/a | 5-10 |
| 600 t/a | 10-15 |
| 900 t/a | 15-20 |

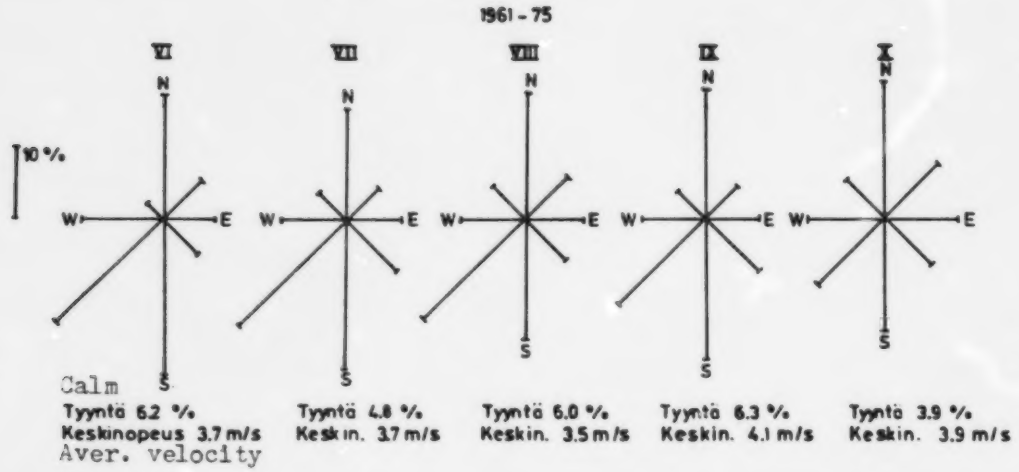
The jobs will materialize on the condition that further processing takes place in the fish farming municipality. Kuivaniemi does not have a fish processing plant, and operations such as Lapplax Ltd. do their processing in Kuusamo.

## 2.3 WEATHER CONDITIONS

11

The wind is the most significant cause of summertime water currents in the area at any given moment. No regular wind observations are available in the Kuivaniemi area. Illustration 2 shows the distribution of winds at the Kemi airport during June-October from 1961 to 1975. Daily observations were made using a wind vane at 6-hour intervals. The prevalent winds in Kemi were southerly (19.0% of the time), southwesterly (18.2%), and northerly (17.4%). The least frequent were northwesterly (5.7% of the time) and northeasterly (7.7%) winds. There was no wind an average 5.4% of the time and the average wind velocity was 3.8 m/s.

Wind conditions can vary greatly in different years and months, as is seen in the wind patterns of 1978-1981 drawn on the basis of the monthly reports of the Meteorological Institute (see Kurkela 1983). September 1981 was the least windy month; the average wind velocity was 2.3 m/s only and there was no wind as much as 10% of the time.




**Kuva 2. Tuulien prosentuaalinen aikajakauma kuukausittain eri ilmansuunnille vuosina 1961 - 75 Kemin lentoasemalla (Ilmatieteen laitoksen kuukausikatsaukset).**

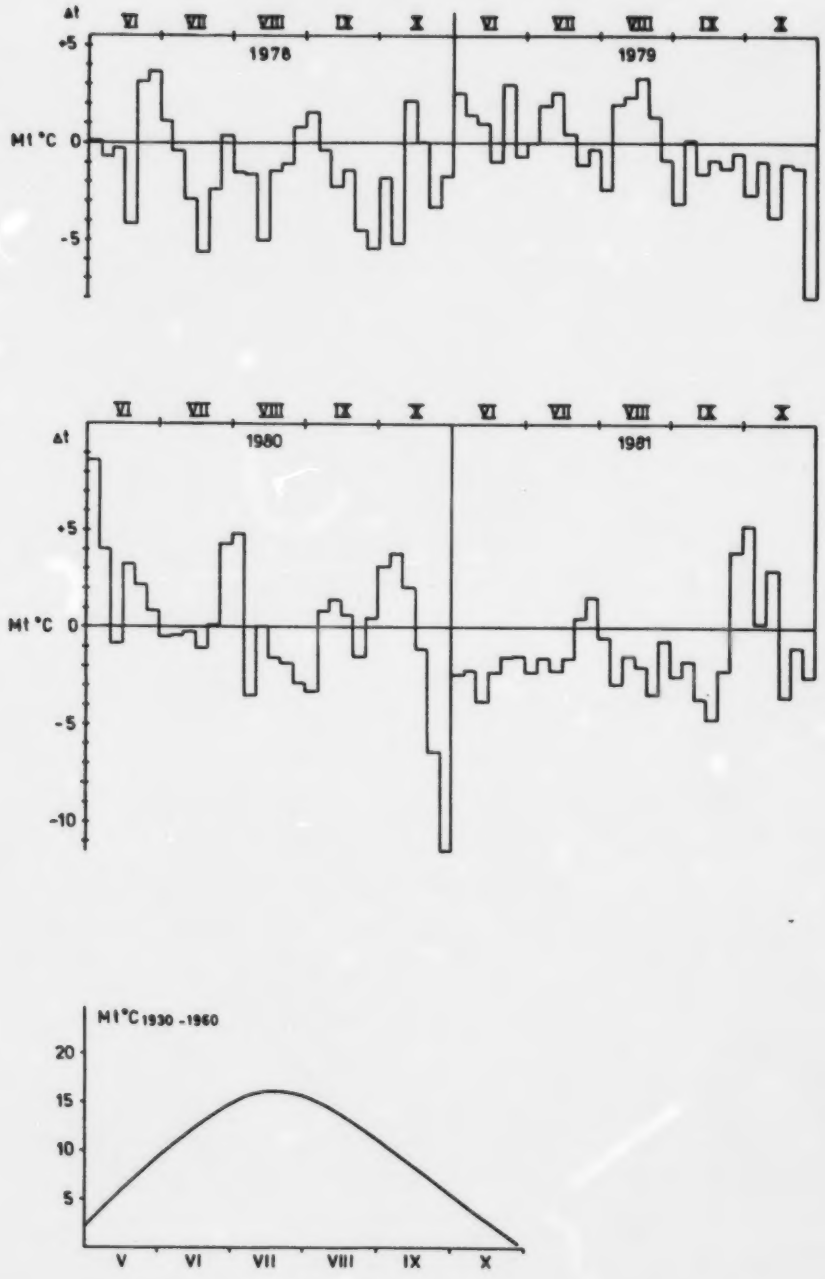
Ill. 2. The time distribution (in %) of winds from different directions monthly from 1961 to 1975 at the Kemi airport (Monthly reports of the Meteorological Institute).

---

According to the Hydrological Yearbook, the average annual precipitation in the Kuivaniemi area during 1961-75 was 629 mm, of which 259 mm as rain during June-September.

Illustration 3 shows temperature changes from June to October, 1978-81. The summer of 1981 was considerably colder than normal. In 1980, the early summer was warmer than usual. The summer of 1978 also had long cold periods.

The period of open water usually lasts an average of 150 days off Kuivaniemi. The sea ice usually breaks up on 20.5. and the sea freezes over on 20.11. on the average (Monthly reports of the Meteorological Institute).




Kuva 3. Ilman lämpötilan poikkeavuus 5 d:n keskilämpötiloina vuosina 1978 - 81 ns. normaalikesän ($Mt^{o}C_{1930-1960}$) lämpötilasta Kemin lentoasemalla /21/.

Illustration 3. Deviation of temperature from the temperature of a so-called normal summer ($Mt^{o}C_{1930-1960}$) measured as average temperatures of 5 days, from 1978 to 1981, at the Kemi airport/21/.

## 2.4 HYDROLOGICAL CONDITIONS



Due to the Coriolis orce (earth's rotation), the average direction of surface currents on the Finnish side of the Gulf of Bothnia is to the north along the coast. However, the effect of the Coriolis orce is so slight that it cannot be used to explain momentary directions of currents in any season.

No actual current measurements have been carried out in the sea off Kuivaniemi. The water current conditions of the area were, however, examined in a water quality prediction issued after an inspection carried out in connection with a fish farming application for 900 t/a by Lapplax Ltd. (Alasaarela and Salmela 1982). The report uses the mathematical water current and mixing model VENLA. Due to the shape of the bottom and the irregularity of the shoreline, an exact determination of the currents is not possible. For a numerical determination, the calculations were based on an area-wide grid, with one side of a square measuring 2 km. To illustrate different situations, the current fields of the area were determined during notherly, easterly and southwesterly winds of a velocity of 5 m/s. During easterly winds, the currents in the area were fairly slow throughout. During southwesterly winds as well, there were areas near the shore where currents were weak. During northerly winds, the current was relatively strong in the entire area (Ill. 4).

Fluctuations in the seawater level have an effect on the circulation and flow of water in the area. A rising seawater level dilutes waste waters and a dropping water level transports waste waters into the open sea. Water currents caused by changes in the water level are determined by winds and pressure differences of marine areas larger than the coastal strip.

Taulukko 2. Meriveden korkeuden vaihtelut vuosina 1956 - 80 teoreettisen keskiveden suhteen (Merenkulkuhallitus, kirjallinen ilmoitus heinäkuu -82).

| | Ajos | Oulu |
|---|---|---|
| HW | +190 | +169 |
| MHW | +118 | +109 |
| MW | 0 | 0 |
| MNW | -88 | -83 |
| NW | -119 | -107 |

Table 2. Changes in the seawater level from 1956 to 1980, based on the theoretical aver. water level (Maritime Administration, written report, July 1982).

During southerly and southwesterly winds, seawater collects in the bay of the Gulf of Bothnia. The water level of the Gulf of Bothnia rose exceptionally high on 22.9.1983 because of a severe autumn storm. The maximum level measured was +163 cm in Oulu and +201 cm in Kemi. Summertime changes in the water level are relatively minor in the sea off Oulu. Towards the end of the year, a rising trend can be observed in the water level (Alasaarela 1978). 15

## 2.5 USE OF THE MARINE AREA

### 2.5.1 Fish farming

First- and second-summer rainbow trout are mainly cultured in the area. The fish are placed in the sea in the spring immediately after the ice is gone and the cages are emptied in October-November so that the fish do not normally overwinter in the sea. According to executive director Martti Palosaari, a few experiments have been carried out to overwinter second-summer fish in net enclosures (verbal comm. 29.11.83) and

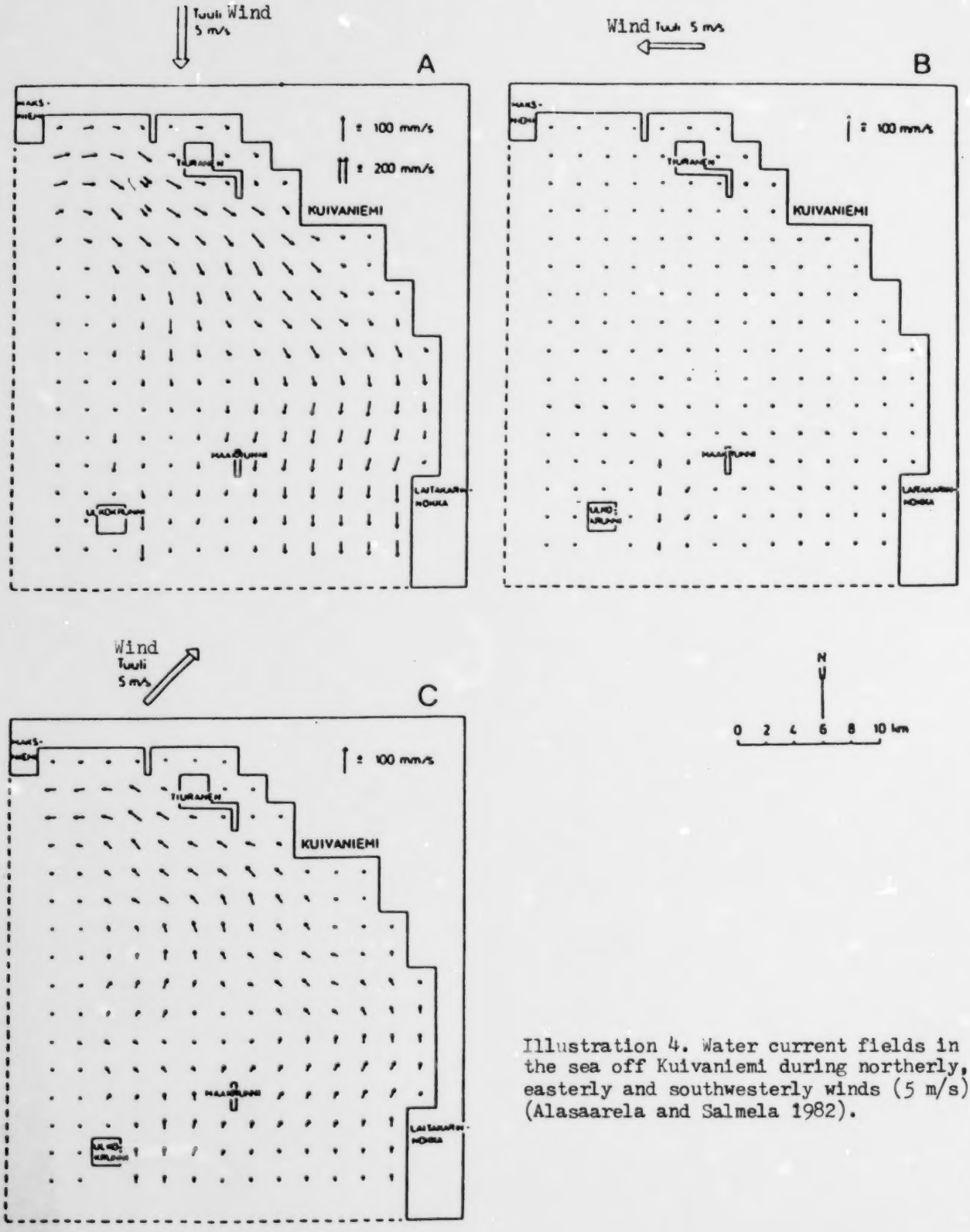



Illustration 4. Water current fields in the sea off Kuivaniemi during northerly, easterly and southwesterly winds (5 m/s) (Alasaarela and Salmela 1982).

**Kuva 4. Virtauskentät Kuivaniemen edustan merialueella pohjois-, itä- ja lounaistuulella (5 m/s) (Alasaarela ja Salmela 1982).**

winter mortality rates were low. Due to the overlapping age groups, the annual production consists of second- and third-summer fish and their growth. First-summer rainbow trout weigh about 10-20 g when they are placed in the sea in the spring, and the weight will have increased to about 300-400 g by the fall. After three summers, the average weight of the fish is about 1,200-1,300 g.

In normal circumstances, the mortality rates of rainbow trout are low (culture loss about 0.5%). The mortality rate naturally rises in adverse circumstances. In the Turku archipelago, the "normal mortality" of rainbow trout has been an average of 3% calculated on the basis of growth (the average of 20 facilities). It fluctuated between 0.7% and 12% in the above cases (verbal comm., build. contr. K. Nurmi, Tuv, 28.11.83). According to executive director Martti Palosaari (verbal comm. 29.11.83), the mortality rates in the Lapplax Ltd. fish farm have fluctuated between 0.2% and 0.5% in the planning area. General vibriosis is a significant cause of death in the Turku archipelago. Due to good water current conditions, no summertime deaths of fish caused by an excessively high water temperature have taken place in the area. According to Palosaari (verbal comm. 29.11.83), the water temperature has not risen any higher than 20°C, heat waves included, in the rearing cages of companies such as Lapplax Ltd.

Escapes by fish are not a problem in terms of water pollution control, although they may result in great financial losses to the fish farmers. Escapes by rainbow trout (e.g. Mauri storm) have not been observed to harm the production of migrant fingerlings in rivers such as Simojoki, at least not so far.

There are 4 licenced facilities in the area (Table 3). Table 4 explains the current and planned fish farming production. Illustration 5 shows

the locations of facilities. The predicted production means the combined amount of the current and planned fish production if all plans known by the Water District materialize fully.

Table 3. Status of fish farm licencing off Kuivaniemi in 1984.

| Facility | Licenced by, date | Max. production permitted | Comments |
|---|---|---|---|
| Lapplax Ltd. | VO 8.8.1978<br>KHO 11.9.1980<br>VO 21.11.1980 | 400 t/a<br>1500 t/a<br>winter storage | permanent licence,<br>statement by Water Dist. on the need of a final inspection 9.11.1984 |
| Perameren Lohi Ltd. | VO 16.10.1978 | 100 t/a | - " - |
| Rousu R. | VO 21.12 1981 | 20 t/a | Licence valid to 1991 |
| Halttu E.[1)] | VO 4.7.1979<br>KHO 12.6.1980<br>VYO 8.5.1981 | 15 t/a | Licence valid to 1985.<br>Not constructed. |

VO = Water Rights Court of North Finland
KHO = Supreme Court of Administration
VYO = Water Court of Appeal
1)The facility is situated on the lower course of Kuivajoki

Table 4. Production (= growth of fish) of fish farms during 1978-83 and production after the planned expansions (prediction) in the planning area. The numbers refer to Illustration 5.

* Some of the fish escaped

** The fish farming location has not been precisely defined

Taulukko 4. Kalankasvatuslaitosten tuotanto (= lisäkasvu) vuosina 1978 - 83 ja tuotanto kaavailtujen lisäysten jälkeen (ennuste) suunnittelualueella. Numerointi viittaa kuvaan 5.

| Location<br>Sijainti | Facility<br>Laitos | No. of facility<br>Laitoksen numero | Kalatuotanto t/a Fish production t/a | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | -78 | -79 | -80 | -81 | -82 | -83 | Ennuste Prediction |
| | Toimivat Operating | | | | | | | | |
| Vatunginnokka | Lapplax Oy | 1 | 180 | 150 | 400 | 365 | 194,6* | 280 | 1 300 |
| Vatunginnokka | Perämeren Lohi Oy | 2 | | | | 6,6 | 30,0 | 26,0 | 100 |
| Halttulanmatala | Rousu | 3 | | | | 3,8 | 7,0 | 11,0 | 20 |
| Halttulanmatala | Åman | 4 | | | | 0,5 | 1,5 | 2,0 | 10 |
| Nierinmatala | Kauppi | 5 | | | | 4,0 | 3,6 | 6,0 | 50 |
| Nierinmatala | Linnatie | 6 | | | | | 9,7 | 20,0 | 20 |
| Kuivajoki, Suukoski | Halttu | 13 | | | | | | | 15 |
| | Suunnitteilla Planned | | | | | | | | |
| Ryöskärinkalla | 5 kpl /facilities | | | | | | | | 425 |
| Lahdenmatala | 1 kpl | | | | | | | | 10 |
| Kuivajoki, Varvinkari | 1 kpl | | | | | | | | 10 |
| Iso Paskaletto Nierinmatala | 1 kpl | | | | | | | | 10 |
| Koivuluodonmatala | 2 kpl | | | | | | | | 140 |
| Vatunginnokka | 1 kpl | | | | | | | | 50 |
| ? ** | 2 kpl | | | | | | | | 10 |
| Yhteensä Total | | | 180 | 150 | 400 | 380 | 246 | 345 | 2 170 |

* Osa kaloista karannut

** Kasvatuspaikkaa ei ole tarkemmin ilmoitettu

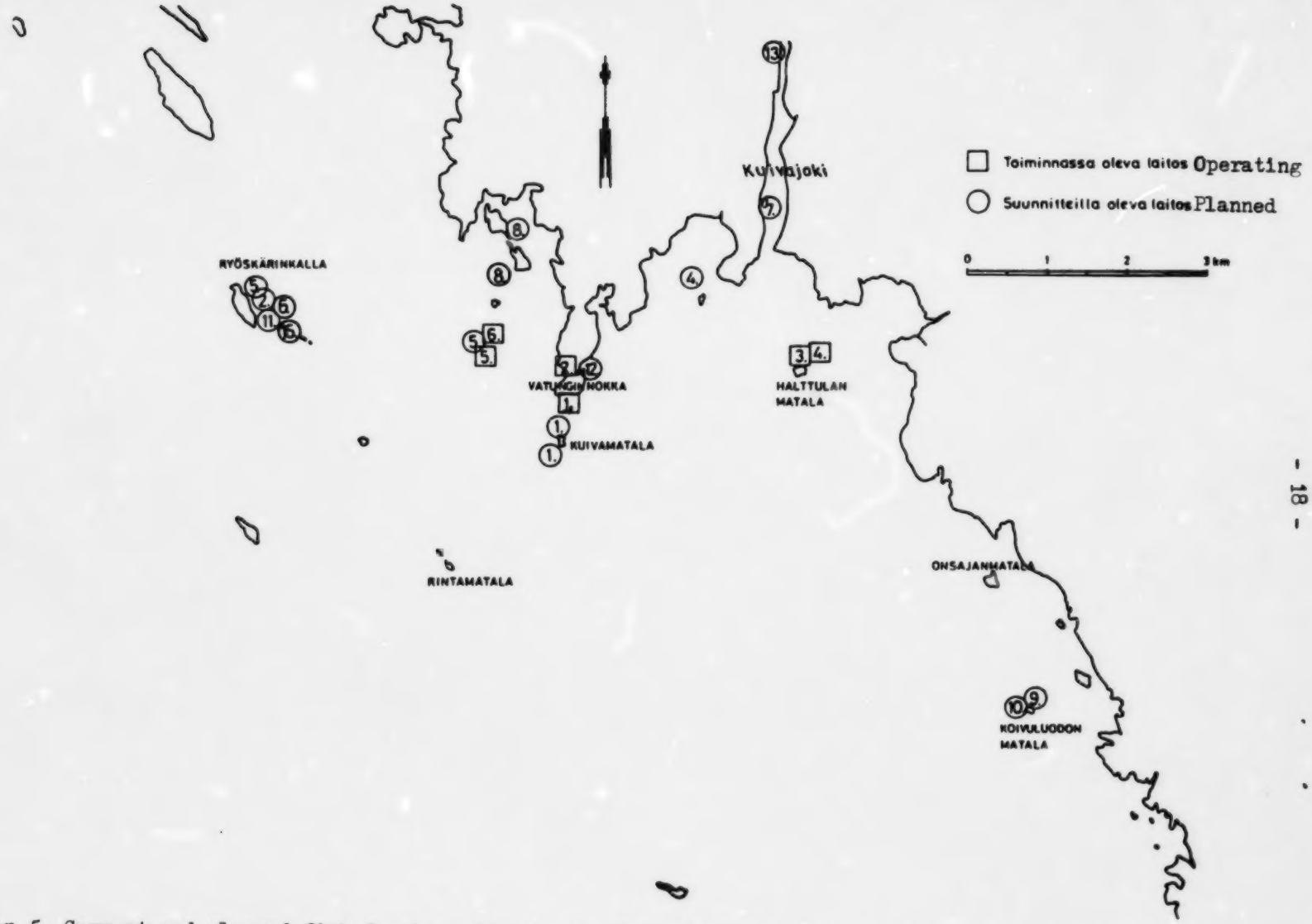



Illustration 5. Current and planned fish farming sites in the Kuivaniemi planning area.
Kuva 5. Kuivaniemen nykyisen ja suunnitellun kalankasvatuksen sijainti suunnittelualueella.

Lapplax Ltd. 18

The largest fish farm of the area is Lapplax Ltd. which started its operations in summer 1978 in Vatunginnokka. The Water Rights Court is currently handling an application by the facility for an additional licence for 900 t/a in Vatunginnokka and southwest of Kuivamatala. The maximum permissible production of the facility is currently 400 t/a and the facility also has a permission to store 1,500 tonnes over the winter in enbankment ponds to be built in Vatunginnokka, but no storage has taken place so far.

The net enclosures of Lapplax Ltd. are situated at the tip of Vatunginnokka. The Allotment Area has rented a water area of 3 ha, to which the operations are currently confined. The planned, additional culture of 900 t/a would take place in three ponds. An enbankment pond of 3.93 ha would be built at the site of the current rearing enclosure in Vatunginnokka, and it would be used as a storage pond in winter. In addition, there would be two smaller storage ponds of 0.43 ha and 0.64 ha near the shoreline. Water in the ponds near the shoreline would change through openings in the enbankments. The planned surface area of the landward rearing pond of Kuivamatala is 3.08 ha and that of the seaward pond 9.50 ha. The larger pond would be divided into four smaller ponds with netting. Docks will be built in the rearing ponds so that the fish can be fed and cared for. Kurkela's introductory chapter discusses aspects such as the structures of the facilities and the prerequisites of marine aquaculture in the planning area in more detail.

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Information seulement

Perameren Lohi Ltd. [Gulf of Bothnia Salmon]

Perameren Lohi started tentative operations in summer 1981. The operations expanded in 1982. The water used by the Perameren Lohi fish farm is pumped to the ponds from the sea. There are six rectangular rearing ponds. They are about 60 m long, 10 m wide and the lenghtwise slope is 1:10. The ponds are built by earthern enbankments whose crest is +3.60 m above the seawater level. From the rearing ponds the water is led to two sedimentation ponds (10.5 m x 70 m). The waste collecting on the bottom is removed at the end of the rearing season.

Other facilities

Other smaller enterprises carry out their fish culture in net cages. Rousu's round cages are made of wire netting and moored to the bottom, and their upper surfaces also have protective netting. The Aman, Linnatie and Kauppi facilities have floating, home-made net cages, in which the nets are stretched onto wooden frameworks.

In addition to the current fish farming, the Water District of Oulu is aware of plans to increase fish farming by a total of 1,620 t/a. In addition to rainbow trout culture, interest has also been expressed in salmon pond culture in the area. 19

2.5.2 Marine fishing

All species of fish naturally occurring in the Gulf of Bothnia are found in the sea off Kuivaniemi. The most important for the fishing industry are Baltic herring, vendace and lavaret. Fishes such as pike, burbot, perch,

roach, sprat, and ruff are also part of the fish population of the area. Salmon and trout stocks have considerably diminished after the damming of Kemijoki and Iijoki. Even cod appear occasionally when a southwesterly wind brings saltier water from the Baltic Sea. Considerable quantities of lampern come up Kuivajoki. Fish stocks are likely to gain strength in the future when the fish management obligations of both Kemijoki and Iijoki take full effect.

Fishing is mostly a secondary occupation in Kuivaniemi. Fishing brings significant supplementary income to many households. Out of the 22 fishermen in Kuivaniemi, six are commercial fishermen; for nine individuals fishing is an active secondary occupation and for seven individuals fishing is a less active secondary occupation (written report 1982, Federation of Gulf of Bothnia Fishermen). Appendix 1 shows fish catches hauled in the sea off Kuivaniemi. The most important species for commercial fishermen is Baltic herring. The 1980 catch totalled 212 t/a. The monetary value of the 1980 catch was 623,000 marks, based on average prices received by commercial fishermen. The significance of fishing in terms of jobs is considerable, taking into account immediate and indirect jobs.

2.5.3 Use of the shore and the islands

The Municipality of Kuivaniemi has 37.4 km of shoreline, of which the islands take up 6.9 km. A subplan of a proposed general plan for the Kuivaniemi seashore classifies the shore east and west of Vatunginnokka and the eastern shore of the mouth of Kuivajoki as excellent. A total of 46.6% of the shoreline has been planned for agricultural and forestry use, 26.7% for coastal housing, and 23.0% for recreation, hiking, sports and tourism services. The proposed subplan specifies a total of 194 construction sites for vacation housing, of which 114 have been built.

The sea off Kuivaniemi constitutes an important environment for activities such as recreational fishing. The official seashore beach is situated on the campgrounds of Rynkynletto and Kaakkurinniemi. However, the most popular beach is the Pankinnokka area at the mouth of Kuivajoki, and an official beach is being planned there.

The largest islands of the area are Iso Paskaletto, Pikku Paskaletto, Ryoskarinkalla, Onsajanmatala, Halttulanmatala, Koivuluodonmatala and Kokkosaari. There are also numerous smaller islands. Islands further out in the marine area in particular serve fishermen and boaters as beaching places.

Of the islands off Kuivaniemi and Olhava, Ryoskarinkalla, Liippa, Samulinmatala, Rintamatala and Hietakalla among others are designated as conservation areas in the regional plan of North Ostrobothnia. The areas are under a flexible degree of conservation. The regional plan shows them as natural environment forests. The regional plan also shows recreational areas within the water zone of the National Water

Administration. Kokkosaari, Rynkynletto and some of Koivuluodonmatala are part of this zone. These recreational areas have been designated as areas where outdoor activities do not require considerable construction. The above islands are natural environment forests managed by the National Forest Administration. According to the proposed subplan, coastal housing is being planned for Iso and Pikku Paskaletto. Halttulanmatala, Lierit, Lahdenmatala, Onsajanmatala, Kokkosaari and Koivuluodonmatala have been planned for recreational and hiking use.

2.5.4 Other uses

Lumber is floated in rafts along the buoyed shipping channel that runs through the area. There is no regularly scheduled service. The incoming channels of the Kotalahti and Selkasaari ports that come under the floating regulations controlling the rafting channel on the coast of the Gulf of Bothnia are also situated in the area.

About ten fishing boats moving primarily further out in the marine area use the Vatunginnokka fishing port as their base. The mouth of Kuivajoki also has a port area meant for small craft.

The wastewater treatment plant of Kuivaniemen Vesi Ltd. discharges its treated wastewater through Kuivajoki into the marine area.

# 3 OPERATIONS THAT ALTER THE MARINE AREA

## 3.1 FISH FARMING

Three kinds of waste included in the waste waters of fish farms enter the recipient body of water:

1. The fecal excrements and urine of the fish, and remains of feed.
2. Chemicals used to treat and prevent diseases.
3. Bacteria and parasites.

In practice, fecal excrements of the fish and remains of feed constitute the most important waste group with respect to water systems. 21

### 3.1.1 Nutrient pollution

Some excrements and remains of feed are carried away directly with the culture water and some settle on the bottom. Nitrogen and phosphorus from the material settling on the bottom dissolve in the water above. According to the most recent research, almost all of the dissolved nutrients of the waste waters of fish farms come from the biological decomposition activity of the sludge (feces). A small percentage is directly secreted as soluble compounds. For example, the extra nitrogen of protein metabolism is actively secreted as ammonium through the gills. Some of the bottom sludge is transported outside the facility mostly with water currents caused by waves.

The fish eat the dry feed quite thoroughly so that hardly any feed as such is carried away into the water system assuming that feed dust is removed before feeding and that overdosage is avoided. Feed waste has greater significance when wet feed is given (Table 5).

Table 5. Percentage of uneaten feed in different brands of feed (Warrer-Hansen 1979).

| Feed | Percentage wasted |
|---|---|
| Wet feed | 10-30% |
| Semi-dry pellet | 5-10% |
| Dry feed | 1-5% |

Since the pollution has its origin in the feed and nutrients dissolve quickly from the sludge (e.g. Kivinen 1980), the distribution of pollution can be largely assumed to correspond to the use of feed. Table 6 presents the montly pattern of feeding according to the day books of Lapplax Ltd. The pollution and effect of the facilities on the water system increase toward the end of the summer. The water warms up and cools down slowly in the Gulf of Bothnia so that feeding gains importance later in the fall than in facilities situated in inland waters. The period of growth and thereby the period of effective feeding can be calculated to consist of 120 days during the summer months.

The amount of pollution is essentially dependent on how well the sludge collecting on the bottoms of the cages can be removed. The sludge is not removed from the net cages of the Kuivaniemi marine area. Due to variable water current conditions, all of the nutrients contained by the settled material escape into the water system.

Wet feed is generally chopped fish, mostly Baltic herring. Semi-dry pellets, which are pellets pressed out of wet feed, are also used. Industrially made dry feeds are most commonly used. Up to 1981, dry feeds contained 1-1.5% of phosphorus. Today, the phosphorus contents of feeds are around 1%, and the so-called water-friendly feeds contain about 0.8% of phosphorus. Dry feed contains 7-8% of nitrogen. The phosphorus content of Baltic herring varies somewhat depending on factors such as the size of the fish and the fishing season. Analyses

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Table 6. Monthly feeding in fish farming, in percentage, according to the day books of Lapplax Ltd.

**Taulukko 6. Kalankasvatuksen ruokinta prosentteina eri kuukausille Lapplax Oy:n hoitopäiväkirjojen mukaan.**

| | | Lapplax Oy | | | | |
|---|---|---|---|---|---|---|
| Month | Kuukausi | 1978 | 1979 | 1980 | 1981 | 1981 - 1982 |
| May | Toukokuu | - | - | 1 % | 1 % | - |
| June | Kesäkuu | - | 2 % | 11 % | 6 % | 6 % |
| July | Heinäkuu | 19 % | 24 % | 38 % | 27 % | 27 % |
| August | Elokuu | 41 % | 34 % | 20 % | 29 % | 29 % |
| September | Syyskuu | 35 % | 34 % | 29 % | 35 % | 35 % |
| October | Lokakuu | 5 % | 6 % | - | 3 % | 3 % |

Table 7. Nutrient pollution of different brands of dry and wet feed per kg of feed given in net cage culture.

**Taulukko 7. Kuivarehun ja tuorerehun ravinnekuormituksia eri rehulaaduilla verkkoallaskasvatuksessa yhtä syötettyä rehukiloa kohti.**

| Polluting factor | Dry feed | | | Wet feed | |
|---|---|---|---|---|---|
| Kuormittava tekijä | Kuivarehu | | | Tuorerehu | |
| Rehun fosforipitoisuus | 0,8 % | 1,0 % | 1,25 % | 0,46 % | P content of feed |
| Rehun typpipitoisuus | 7,5 % | 7,5 % | 7,5 % | 2,44 % | N content of feed |
| Kalankasvu | 560 g | 560 g | 560 g | 170 g | Growth of fish |
| Altaaseen tuleva fosforimäärä | 8,0 g | 10 g | 12,5 g | 4,6 g | P entering cage |
| Altaaseen tuleva typpimäärä | 75 g | 75 g | 75 g | 24,4 g | N entering cage |
| Kalaan jäävä fosforimäärä | 2,2 g | 2,2 g | 2,2 g | 0,7 g | P binding w. fish |
| Kalaan jäävä typpimäärä | 14,6 g | 14,6 g | 14,6 g | 4,4 g | N binding w. fish |
| Vesistöön joutuva fosforimäärä | 5,8 g | 7,8 g | 10,3 g | 3,9 g | P and escaping into the water system |
| Vesistöön joutuva typpimäärä | 60,4 g | 60,4 g | 60,4 g | 20,0 g | N |

carried out by the Water District of Turku came up with an average content of 0.46% of phosphorus for the Baltic herring (Water Division of the Water District of Turku 1984). Table 7 explains the nutrient pollution caused by different brands of dry and wet feed. The calculations use a feed conversion factor of 1.8 for dry feed and 6.0 for wet feed, and 0.4% as the phosphorus content and 2.6% as the nitrogen content of the fish muscle.

When the pollution loads effects of different facilities are being calculated, a specific pollution value of 10 g P/kg of feed is used for net gage facilities up to 1981. The pollution estimates of 1982-83 and the prediction are based on 7 g P/kg of feed. Estimates of nitrogen pollution are based on 60 g N/kg of feed. The corresponding values for wet feed are 3.9 g P/kg of feed and 20 g N/kg of feed (see Table 7). For earthen ponds, the estimates of 6 g P/kg of feed and 30 g N/kg of 23
feed are used, as suggested by the guidelines of the National Water Administration. The pollution readings are presented in Table 8.

The phosphorus of the 1983 production corresponds approximately to 24
the untreated housing sewage of 11,400 inhabitants and the 80%-treated housing sewage of 57,500 inhabitants. The phosphorus pollution of the planned 2,170 t/a production corresponds to the untreated sewage of 75,500 inhabitants and to the 80%-treated housing sewage of 377,000 inhabitants.

### 3.1.2 Hygienic load pollution

Species of bacteria that are common in the intestines of homeotherms but uncommon in other environments are used as indicator bacteria to indicate hygienic conditions. The most important group is coliform bacteria, of which fecal coliform bacteria in particular are used as an indicator group. Water hygiene is also commonly studied by determining the number of fecal streptococci. The fish farms regularly produce both general coliform bacteria and fecal streptococci in summer. On the other hand, the waste waters of fish farms do not normally contain any more fecal coliform bacteria than the incoming water. Retesting has shown the fecal streptococci to be non-fecal species so that they do not appear to be the right tool to monitor the hygiene of the waste waters of fish

Table 8. Estimated daily nutrient pollution of existing and planned facilities in the sea off Kuivaniemi during the growing season (120 days). Estimate criteria in the text. Prediction = combined pollution of the present and planned fish production, if all the plans known by the Water District materialize fully.

**Taulukko 8. Arvio Kuivaniemen edustan alueella olevien ja suunniteltujen laitosten vuorokautiset ravinnekuormitukset kasvukautena (120 d). Arvioperusteet tekstissä. Ennuste = nykyisen ja suunnitellun kalatuotannon yhteenlaskettu kuormitus, jos kaikki vesipiirin tietoon tulleet kaavailut toteutuisivat täysimääräisinä.**

* Estimated on the basis of production
Arvioitu tuotannon perusteella

| | | Lapplax | Perämeren Lohi | Rousu | Åman | Kauppi | Linnatie | Suunnitellut laitokset Planned facilities | Yhteensä Total |
|---|---|---|---|---|---|---|---|---|---|
| | 1978 | | | | | | | | |
| | Kuivarehu | 360,0* | | | | | | | 360,0 |
| | P-kuormitus | 30,0 | | | | | | | 30,0 |
| | N-kuormitus | 180,0 | | | | | | | 180,0 |
| | 1979 | | | | | | | | |
| | Kuivarehu | 301,2 | | | | | | | 301,2 |
| | P-kuormitus | 25,1 | | | | | | | 25,1 |
| | N-kuormitus | 150,6 | | | | | | | 150,6 |
| | 1980 | | | | | | | | |
| Dry feed | Kuivarehu | 650,0 | | | | | | | 650,0 |
| Wet feed | Tuorerehu | 80,0 | | | | | | | 80,0 |
| P-pollution | P-kuormitus | 56,8 | | | | | | | 56,8 |
| N-pollution | N-kuormitus | 338,3 | | | | | | | 338,3 |
| load | | | | | | | | | |
| | 1981 | | | | | | | | |
| | Kuivarehu | 579,8 | 9,0 | 1,6 | 0,7 | 0,5 | 0,5 | | 592,1 |
| | Tuorerehu | | 10,5 | 7,6 | 1,8 | 18,0 | 15,0 | | 52,9 |
| | P-kuormitus | 48,3 | 0,8 | 0,4 | 0,1 | 0,6 | 0,5 | | 50,7 |
| | N-kuormitus | 289,9 | 4,0 | 2,1 | 0,7 | 3,3 | 2,8 | | 302,8 |
| | 1982 | | | | | | | | |
| | Kuivarehu | 306,5 | 65,3 | 9,0 | 1,1 | 5,3 | 8,7 | | 395,9 |
| | Tuorerehu | | | | 2,0 | 4,0 | 17,4 | | 23,4 |
| | P-kuormitus | 17,9 | 3,3 | 0,5 | 0,1 | 0,4 | 1,1 | | 23,3 |
| | N-kuormitus | 153,3 | 16,3 | 4,5 | 0,9 | 3,3 | 7,3 | | 185,6 |
| | 1983 | | | | | | | | |
| | Kuivarehu | 467,0 | 52,4 | 20,0 | 3,5 | 10,0 | 30,0 | | 582,9 |
| | Tuorerehu | | | | 2,0 | 12,0 | | | 14,0 |
| | P-kuormitus | 27,2 | 2,6 | 1,2 | 0,3 | 1,0 | 1,8 | | 34,1 |
| | N-kuormitus | 233,5 | 13,1 | 10,0 | 2,1 | 7,0 | 15,0 | | 280,7 |
| | Ennuste | | | | | | | | |
| | Kuivarehu | 2 340 | 540 | 36 | 36 | 180 | 126 | 648 | 3 906 |
| | P-kuormitus | 136,5 | 30,0 | 2,1 | 2,1 | 10,5 | 7,4 | 37,8 | 226,4 |
| | N-kuormitus | 1170,0 | 225,0 | 18,0 | 18,0 | 90,0 | 63,0 | 324,0 | 1 908,0 |

farms (Niemi 1984). Intestinal bacteria of fish have indicator value when the distribution range of waste waters is estimated. The bacteria found in fish farms have not been observed to cause epidemic diseases in humans or homeothermic animals.

Fish mortality also brings about hygienic pollution. While the mortality rate is very low in ordinary circumstances, the rate can rise to a few dozen per cent in some diseases or other catastrophic situations. For instance, a 20% mortality out of a production of 700 tonnes means about 180 tonnes of dead and rotting fish, of which the majority are on the bottom of the cage. If the dead fish are not removed quickly enough from the cages, they may bring about a deterioration in the hygienic state of the water system.

3.1.3 Fish diseases

The most hazardous diseases associated with fish culture are highly contagious viral (e.g. VHS and IPS) or bacterial (e.g. furunculosis and vibriosis) diseases. The most important disease in marine aquaculture is vibriosis, which reduces the annual production by a financially considerable amount because of mortality and weakened growth. If untreated, the disease can result in mortality rates of dozens of per cent. The vibriosis bacterium needs saline water to multiply. Due to the low salinity content, the probability of vibriosis is low in the planning area, although the disease cannot be completely discounted. (verbal comm. Perttu Koski, 31.11.83).

Flushing and different drugs given with the feed are used to treat fish diseases and parasitic infestations. Drugs have not been found to cause any problem in terms of water pollution control. 25

## 3.2 RIVERS

In winter, river waters collect into a blanket under the ice. The bottom part of the blanket mixes with the seawater.

In summer, river waters mix with the seawater because of the effect of the wind, and distinct stratification takes place in early summer only (Alasaarela 1978).

Kuivajoki is the only river flowing directly into the planning area. The catchment basin of Kuivajoki is 1,340 km² and the lake percentage is 2.7% (Ill. 6).

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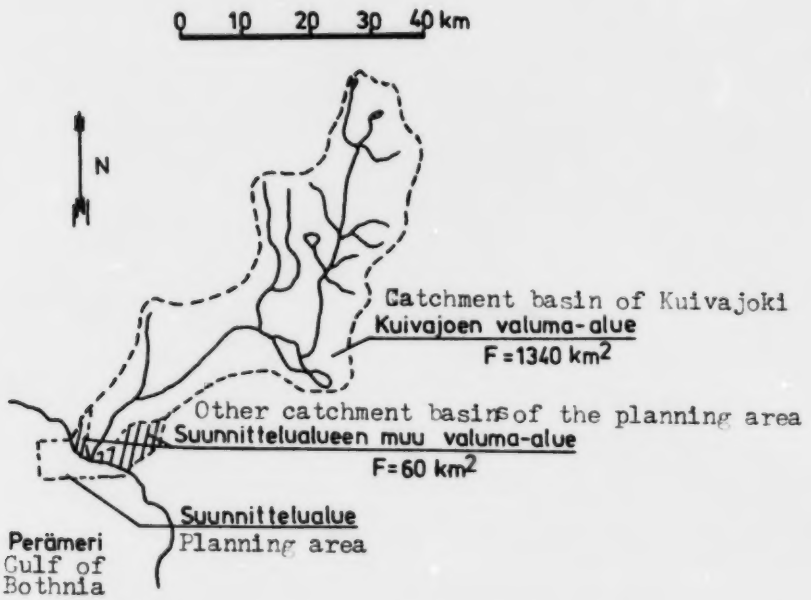
Illustration 6. The planning area and catchment basins flowing into it.




**Kuva 6. Suunnittelualue ja sille purkautuvat valuma-alueet.**

The water quality of Kuivajoki has been observed in connection with the mandatory monitoring of Kuivaniemen Vesi Ltd. The average phosphorus content has been about 31 µg/L and the nitrogen content about 466 µg/L in summer. The corresponding phosphorus content has been about 66 µg/L and the nitrogen content about 1,090 µg/L in winter. Table 9 shows the average monthly discharges and nutrient amounts of Kuivajoki (Kurkela 1983). The majority of the nutrient discharge arrives with the spring flood. A lot of humus also enters the area with river waters.

The amounts of material arriving from outside the Kuivajoki catchment basin (III. 6) are calculated on the basis of the ratio of the catchment basin in question (60 km²) and the Kuivajoki catchment area. The phosphorus discharge entering the planning area has been calculated this way as 2.2 kg P/day and the nitrogen pollution as 34 kg N/day.

Table 9. The nutrient discharges of Kuivajoki as monthly averages (Kurkela 1983).

**Taulukko 9. Kuivajoen ravinnevirtaamat kuukausikeskiarvoina (Kurkela 1983).**

| Month | | | P discharge | N discharge |
|---|---|---|---|---|
| | **Kuukausi** | $MQ_{1965-75}$ ($m^3/s$) | **Fosforivirtaama** (kg P/d) | **Typpivirtaama** (kg N/d) |
| Jan | **Tammikuu** | 4,3 | 25 | 405 |
| Feb | **Helmikuu** | 3,4 | 19 | 320 |
| Mar | **Maaliskuu** | 2,7 | 15 | 254 |
| Apr | **Huhtikuu** | 12,0 | 68 | 1 130 |
| May | **Toukokuu** | 89 | 238 | 3 583 |
| Jun | **Kesäkuu** | 14,1 | 38 | 567 |
| Jul | **Heinäkuu** | 6,7 | 18 | 270 |
| Aug | **Elokuu** | 7,5 | 20 | 302 |
| Sep | **Syyskuu** | 10,4 | 28 | 419 |
| Oct | **Lokakuu** | 15,2 | 41 | 612 |
| Nov | **Marraskuu** | 15,1 | 40 | 608 |
| Dec | **Joulukuu** | 6,5 | 37 | 612 |

The material discharges of Kuivajoki consist of natural leaching, scattered pollution and sewage waters. Kuivajoki would carry a certain amount of materials such as nutrients into the planning area even if no human activity at all took place in the area. This is part of the natural cycle of materials and it is not pollution in the same sense as pollution caused by human activity is. It can be roughly estimated that only a little over one half of the nutrient discharge of Kuivajoki is actual pollution. The entire material discharge of Kuivajoki naturally affects the state and contents of the marine area. 26

## 3.3 POLLUTION OFF KEMI AND OULU

The wood processing plants of Kemi Ltd. and Veitsiluoto Ltd. pollute the sea off Kemi. Sewage treatment plants were completed in 1982 to treat the housing sewage of the city of Kemi and the municipality of Keminmaa. The largest wastewater polluters of the sea off Oulu are the city of Oulu, Kemira Ltd., Oulu Ltd., and Kajaani Ltd. Table 10 shows the nutrient pollution of the sea off Kemi and Oulu in 1978-83 (Water Research Division of North Finland 1984a and 1984b).

The spreading of waste waters in the marine area is not the same in summer and in winter. According to the mandatory monitoring reports, the definite area of impact in the sea off Kemi is in summer the area bordered by Pajusaari - Selkasaari - Ahos - the mainland, and Veitsiluodonlahti. The area affected by Oulujoki and its waste waters can be defined as the marine area from Siikajoki to Iijoki. The impact of the waste waters of Oulu and Kemi do therefore not extend to the planning area, at least not in summer.

Table 10. The total nitrogen and phosphorus pollution of the sea off Kemi and Oulu in 1978-83. Contains the combined pollution by industry and housing sewage (Water Research Division of North Finland 1984a and 1984b).

**Taulukko 10. Kemin ja Oulun edustan kokonaistyppi- ja kokonaisfosforikuormitus v. 1978 - 83. Sisältää teollisuuden ja asumajätevesien yhteenlasketun kuormituksen (Pohjois-Suomen Vesitutkimustoimisto 1984a ja 1984b).**

| Year<br>Vuosi | Off Kemi<br>Kemin edusta | | | Off Oulu<br>Oulun edusta | | |
|---|---|---|---|---|---|---|
| | total P<br>kok. P | | total N<br>kok. N | total P<br>kok. P | | total N<br>kok. N |
| | t/a | kg/oper./käynti d | t/a | t/a | kg/oper./käynti d | t/a |
| 1978 | 194 | 805 | 58 | 183 | 1 056 | 2 992 |
| 1979 | 165 | 953 | 60 | 171 | 1 065 | 2 951 |
| 1980 | 218 | 928 | 54 | 155 | 1 077 | 2 989 |
| 1981 | 213 | 1 101 | 54 | 157 | 1 024 | 2 839 |
| 1982 | 161 | 1 002 | 50 | 159 | 834 | 2 403 |
| 1983 | 147 | (706)* | 46 | 138 | 874 | 2 442 |

* puuttuu asumajätevedet housing sewage not included

3.4 FALLOUT FROM THE AIR 27

The nutrient fallout settling from the air onto the planning area has been estimated on the basis of the Hailuoto rainfall station, which is closest to Kuivaniemi. The samples are collected so that they contain all the material that settled into the containers during a month. Jarvinen & Haapala (1980) came up with an average fallout of about 0.8 mg/m² of phosphorus per month and about 42 mg/m² of nitrogen per month in 1971-1977. The water surface of the planning area is about 140 km² so that the average nutrient fallout is found to be 112 kg P/month and 5,880 kg N/month. The estimating of the summertime fallout is very imprecise. Using a grouping of summer and winter months as a base, Haapala (1972) came up with an average monthly fallout of 2.1 mg P/m² /month in the whole country in winter and 5.1 mg P/m²/month in summer,

which means that the summer fallouts constituted about 71% of the annual fallouts. The averate daily fallout of Kuivaniemi is found to be 5.2 kg P/day in summer if the same ratio is used. There is no such distinct fluctuation between the nitrogen fallouts of summer and winter and the average daily nitrogen fallout in summer is found to be 193 kg N/day in summer.

Due to the measurement procedure, the above method may indicate overly high amounts of materials because the samples contain materials such as dust raised from the ground by the wind. Fallouts measured within water systems proper have indeed been smaller than values measured on land. Only the extra fallout coming in excess of the natural nutrient level constitutes pollution proper. This extra fallout appears to be minor in the planning area. According to long-range observations of the National Water Administration, pollution from the air cannot be shown to have increased during the last few decades -other than in areas immediately adjacent to industrial zones - as far as factors affecting the eutrophication of water systems is concerned (Jarvinen & Haapala 1980). On the other hand, the amounts of strong acids in rainwater have clearly increased. 28

## 3.5 SUMMARY OF OPERATIONS THAT ALTER THE MARINE AREA

The harmful impact of pollution on water systems is generally most significant in two seasons. In early spring, a lower oxygen content is a problem while excessive eutrophication is a problem in summer. When fish culture is expanding vigorously, eutrophication is feared to become a factor limiting the use of the water system, and different polluters must therefore be examined specifically in summer.

Materials carried by river waters enter the sea mostly during spring and fall floods. The amounts of material are considerably smaller in summer. In winter, river waters collect into a blanket at the surface under the ice. The pollution off Kemi and Oulu does not extend to the area off Kuivaniemi in summer, because water currents caused by winds mix the waters quickly. Pollution caused by fish culture occurs mostly in summer, peaking in August-September. Feeding of the fish is sparse during winter storage. No winter storage has taken place in the planning area yet.

If the amounts of material are directly compared, a false impression is created of the impact of different factors on the water system. The situation can be illustrated with the following example. If a large river (discharge 300 $m^3/s$) with a material content of 5 µg/L flows into the area being examined (volume 10 µg/L), the river causes a "pollution" of 129.6 kg when in fact the river dilutes the contents.

The following will present for comparison's sake what impact different activities have on the mixed contents of the planning area (water volume 0.9 $km^3$ and content 8.6 µg P/L) in summer (120 days):

| Activity | Phosph. increment | Mixed content | Change in content |
|---|---|---|---|
| | kg/120 days | µg/L | µg/L |
| Fish farming 1983 | 4,092 | 13.2 | + 4.6 |
| Fish farming prediction | 27,120 | 38.7 | +30.1 |
| Catchment basin (discharge 10.1 $m^3/s$) | 3.240 | 10.9 | + 2.3 |
| Fallout from the air + from rain (rainfall 259 mm) | 624 | 8.9 | + 0.3 |

The theoretical mixed contents do not reflect the actual contents which are reduced by currents, mixing, sedimentation, etc. The effects of spot polluters (fish culture, sewage waters) have an impact on a given,

limited area of water so that the material contents of areas adjacent to the discharge location rise. The materials of isolated pollution spread to a large area so that the content increments caused by them remain smaller. The nutrients of waste waters are also in a form more useful to algae than nutrients arriving with scattered pollution.

The summertime nutrient contents of the marine area off Kuivaniemi rise mostly because of fish farming and partially because of nutrient amounts arriving from the catchment basin. Fish farming whose phosphorus pollution can be predicted to rise to a maximum of 226 kg P/day, is becoming the most important factor among these. The daily summertime phosphorus pollution of fish farming is more than one third greater than the current combined pollution of industry and housing off Oulu or Kemi. Calculated on an annual basis, it is about one half of the latter.

## 4 STATE AND USABILITY OF THE MARINE AREA

The state of the sea off Kuivaniemi has been observed through the mandatory monitoring of Lapplax Ltd. and Perameren Lohi Ltd. (Ill. 7). Samples were taken twice every summer during 1978-80 (Appendix 2). Since 1981, the number of sampling has been four times during the summer and once during the winter.

A study covering the entire northeastern part of the Gulf of Bothnia was carried out in connection with the general biological studies of the sea off Oulu and Kemi in 1975-1977 (Alasaarela 1978a and 1978b). The water quality of the open sea of the Gulf of Bothnia was studied in connection with a project directed by the Gulf of Bothnia Research Station of the University of Oulu in 1976-77. The national marine

observation station for the sea off Kuivaniemi is situated about 3.5 km south of Vatunginnokka.

The water quality of Kuivajoki has been observed since 1978 in connection with the mandatory monitoring of Kuivaniemen Vesi Ltd.

In connection with the inspection of Lapplax Ltd. in summer 1978, sliming tests on netting were carried out once in June and September and twice in July and August in identical locations (Appendix 3).

The harmful impact of fish farming pollutants manifests itself in the fouling of fishing implements, clouding by algae along the shore and sliminess of the bottom. The fouling of fishing implements reduces catches and increases the work of fishermen when they have to clean the implements. Fish culture is suspected of reducing catches of Baltic

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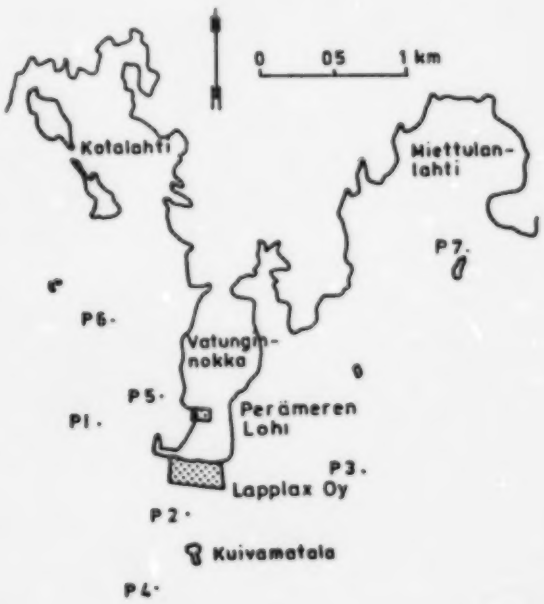
Illustration 7. Observation locations in Vatunginnokka in 1982.




Kuva 7. Vatunginnokan tarkkailupaikat v. 1982.

herring in some areas of the Turku archipelago (Water Division of the Water District of Turku 1984). The Water District and the Game and Fishing Research Institute and jointly looking into the matter. Clouding by algae along the shore and sliminess of the bottom reduce the recreational value. A deteriorating hygienic state of the water reduces the suitability of an area adjacent to a fish farm for swimming.

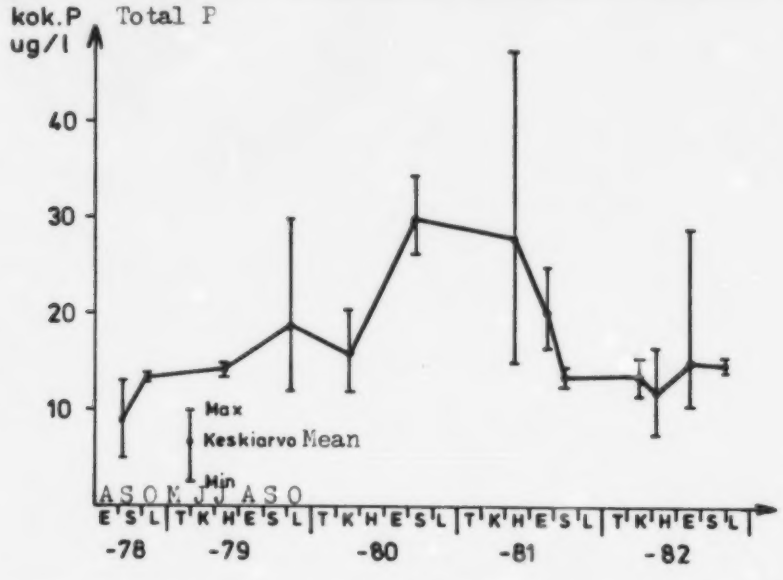
## 4.1 PHYSIOCHEMICAL AND HYGIENIC STATE

River waters and waste waters raise the phosphorus content of the planning area. The total phosphorus content of the sea off Kuivanieri was 20-30 µg/L in late winter and about 12-15 µg/L in August in 1975-77, i.e. before the beginning of fish farming operations (Alasaarela 1978a). According to the mandatory monitoring, the total phosphorus content of the vicinity of Vatunginnokka was about 20 µg/L in 1978-82, with the maximum readings rising considerably higher in the vicinity of the fish farms (Ill. 8). The phosphorus content of the open sea is about 9 µg/L in summer.

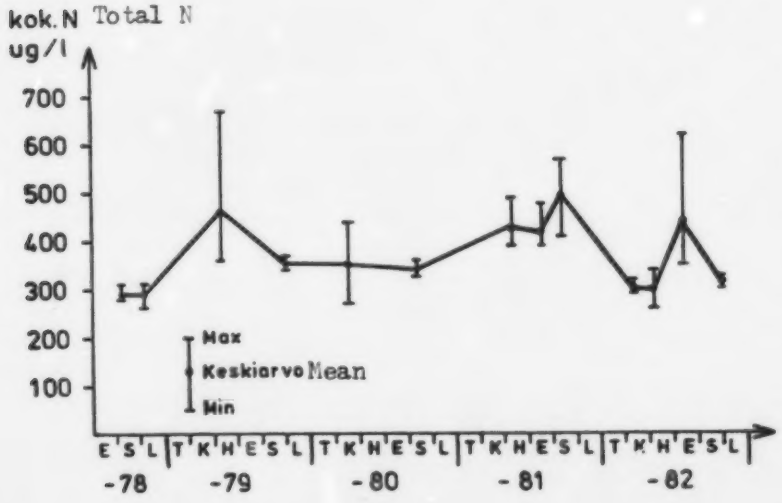
Humus contains a lot of nitrogen but it is mostly organically bound and disintegrates very slowly. The average content of total nitrogen in the sea off Kuivaniemi has been 400-700 µg/L in winter and about 300-330 µg/L in winter in 1975-1977 (Alasaarela 1978b). According to the mandatory monitoring, the nitrogen content of the vicinity of Vatunginnokka rose from about 380 µg/L in summer 1978 to 400-500 µg/L in summer 1981 (Ill.9). The readings of summer 1981 were considerably higher in the surface water than near the bottom. Probably due to the rainy summer, river waters dominated near the surface. The total nitrogen content varied between 210 and 500 µg/L further out in the marine area. The nitrogen content was fairly high (500-600 µg/L) in early summer, but the readings dropped as low as close to 300 µg/L in mid-summer.

Illustration 8. Total phosphorus contents of the mandatory monitoring locations (see Ill. 7) in the vicinity of Vatunginnokka in 1978-1982. The mean of the phosphorus content readings of the surface and bottom samples has been used as the reading of the monitoring location.

Illustration 9. Total nitrogen contents of the mandatory monitoring locations (see Ill. 7) in the vicinity of Vatunginnokka in 1978-1982. The mean of the nitrogen content readings of the surface and bottom samples has been used as the reading of the monitoring location.




Kuva 8. Velvoitetarkkailupaikkojen (katso kuva 7) kokonaisfosforipitoisuudet Vatunginnokan lähistöllä v. 1978 - 1982. Havaintopaikan fosforipitoisuusarvona käytetty pinta- ja pohjanäytteen keskiarvoa.




Kuva 9. Velvoitetarkkailupaikkojen (katso kuva 7) kokonaistyppipitoisuudet Vatunginnokan lähistöllä v. 1978 - 1982. Havaintopaikan typpipitoisuusarvona käytetty pinta- ja pohjanäytteen keskiarvoa.

It has been noted that the summertime water temperature of the sea off Kuivaniemi is somewhat lower near the bottom than at the surface in 32
the sea off Kuivaniemi, but because of the shallowness of the area, no clear stratification can be observed. The seawater was warmest in May 1980, when the temperature rose to 18°C. The temperatures are generally about 0.5-2.0°C lower further out in the marine area than close to the shore.

The oxygen situation of the area has been relatively good in summer. The lowest oxygen content reading was 68%, occuring west of Vatunginnokka in July 1979. Supersaturation in the oxygen content has been observed in early summer, but the readings have settled around 90% in late summer. In April 1982, the oxygen contents of the samples were between 63 and 73% near the bottom. The readings were about 10% higher in the surface water. The oxygen situation of winter depends on how the waste waters of Kemi move under the ice.

The pH dropped to between 6.7 and 7.3 in the samples of July 1981. The readings were about 7.3-7.8 during other summers. The pH readings have generally been higher in late summer than in early summer. The rise in the pH readings is probably due to an increase in the amount of phytoplankton toward the late summer.

Electrical conductivity in the marine area represents an effect of river water. In 1981, the percentage of water contributed by rivers was about 50-80% because of the rainy summer. Also in summer 1979, the amounts of river water were larger than normal or about 45% at the time of sampling. The readings of early summer show the effect of river waters brought by spring floods. The amount of river water is smallest in August-September. The readings of April 1982 show how river waters collect into a surface layer during the winter.

The colour and the chemical oxygen demand (COD) represent factors such as the amount of humus in the water. Organic pollution also affects the COD. The primary contributors to the brown colour of the water are river waters. The colour values of the water clearly show that the amounts of river water were large in summer 1981. The COD readings were highest in summer 1981.

River waters and waste waters bring solid material to the marine area. The phytoplankton also affects the summertime quantity of solid material. The highest contents of solid material were found in the vicinity of Vatunginnokka in the fall of 1980. The contents of solid material have generally been higher in the surface water than near the bottom. The contents of solid material have been lower further out in the marine area than near the shore.

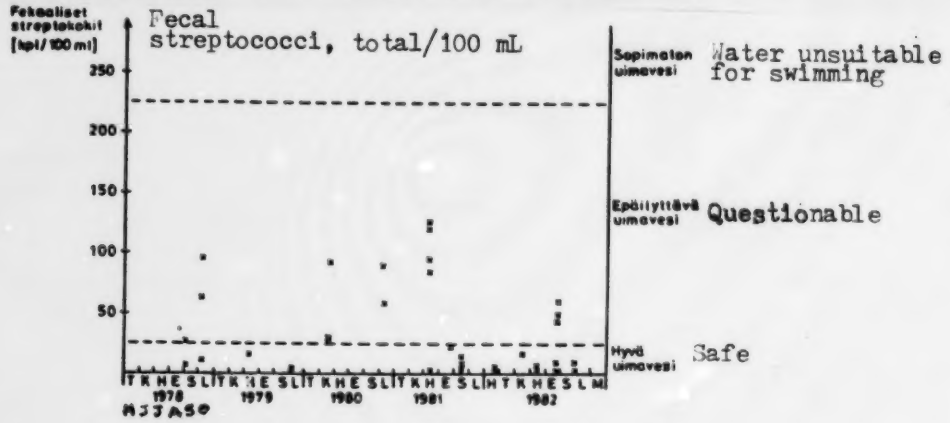
To study the hygienic state of the water, bacteria normally present in the intestines of humans and homeotherms are determined. The usability of the water within microbiological standards is determined on the basis of the quantity of these indicator bacteria. The quantity of fecal streptococci in the vicinity of Vatunginnokka has been found to exceed the limit recommended by the National Health Administration for safe swimming in all fish farming years except 1979 (Ill. 10). 33

## 4.2 EFFECT OF POLLUTION ON THE STATE OF THE MARINE AREA

Fish farming accounts for most of the total pollution of the planning area in summer. Polluters other than fish farming have grown little during the last 5 years.

The phosphorus content of the water of Kuivajoki is 20-40 µg/L in summer, which is about three to five times more than the phosphorus content of seawater outside the effect of river water. The

Illustration 10. Quantities of fecal streptococci in different observation locations near Vatunginnokka in 1978-1982.




**Kuva 10. Fekaalisten streptokokkien määrät eri havaintopaikoissa Vatunginnokan lähistöllä v. 1978 - 1982.**

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total nitrogen content of Kuivajoki is only once or twice that of seawater. The waters of Kuivajoki have a reducing effect on the nitrogen/phosphorus ratio of the marine area. In other words, the river waters have the effect that nitrogen is becoming a minimum factor in the marine area. Due to the fairly small discharge, a relatively small amount of nutrients usable by primary production enters the sea off Kuivaniemi with river waters in summer.

When the present water quality in the vicinity of Vatunginnokka is compared to the situation in 1975-1977 when the area had no fish farms, the phosphorus contents seem to have grown about 1.5 to 2.0 times higher and the nitrogen contents about 1 to 1.5 times higher. The estimates are fairly unreliable because samples were taken once a year only, in August, from 1975 to 1977. The wintertime nutrient contents have remained about the same.

The fish farms have also made themselves felt in the deterioration of the hygienic state of their vicinity.

The phosphorus pollution of fish farms will also have a certain impact on the trophic level of the coastal area off Kuivaniemi. This cause will be a fairly constant factor from year to year. Weather factors affecting the state of the area are, on the other hand, not constant and annual differences in them can be considerable. The most important external, mainly weather-dependent factors which have negative effects on the state of the area are the following:

| Cause | Effect |
|---|---|
| 1. wind conditions -westerly and southwesterly wind | river waters and polluting waters from fish farms collect in the coastal area (low dilution level) |
| -easterly and northeasterly wind | water current conditions weak overall (low dilution level) |
| -long-lasting gentle wind | river waters and polluting waters from fish farms collect into surface layers (low dilution level), quick warming of waters due to possible warm, sunny weather |
| 2. slow change in seawater level | insignificant circulation of waters (low dilution level) |
| 3. low discharge of rivers | poor dilution of waste waters |
| 4. warm, sunny weather | warming of water, quickening of biological activities |

The VENLA water-quality model has been used to study the relationship between the condition of a marine area and pollution caused by fish farming. The model was presented in more detail in a report on the application of water-quality prediction models (Eloranta et al. 1981). The following phosphorus discharges off Vatunginnokka were used as fish farming pollution alternatives: 30 kg P/d, 70 kg P/d, 120 kg P/d and 160 kg P/d. A phosphorus discharge of 43.2 kg/d was used for the water of Kuivajoki (Alasaarela and Salmela 1982). Assuming 7 g P/kg of feed with a specific pollution value and feed conversion factor of 2, a phosphorus

pollution of 30 kg/d corresponds to an additional growth of about 257 t, 70 kg/d to about 600 t, 120 kg/d to about 1,029 t and a pollution of 160 kg P/d to about 1,371 t of additional growth.

During a constant wind of 5 m/s, the phosphorus contents of open areas stabilized relatively quickly, in about 2-3 days within a 10-km radius from the discharge point. Stabilizing may, however, take a couple of weeks in the coastal coves and behind islands. In a stable situation, a phosphorus pollution of 160 kg/d spreads over about 20 km² during a northerly wind, over about 50 km² during a southwesterly wind and over more than 100 km² during an easterly wind (Ill. 11). If there are no currents, the concentrations spread so slowly that they do not correspond to any naturally occurring situation. A reading of 8.6 µg P/L was used to represent the background phosphorus content of the sea. 35

Illustration 12 shows how an increase in pollution affects the phosphorus contents of various spots during an easterly wind (5 m/s). 15 µg P/L was estimated to be the background phosphorus content of the coastal area. A phosphorus pollution of 230 kg/d will result in a phosphorus content exceeding 25 µg/L about 1 km from the pollution location, 32 kg P/d about 4 km from the location and 360 kg P/d about 12 km from the pollution location. Correspondingly, 115 kg P/d will result in a phosphorus content exceeding 20 µg/L about 1 km from the pollution location, 165 kg P/d about 4 km and 190 kg P/d about 12 km from the pollution location (Ill. 12).

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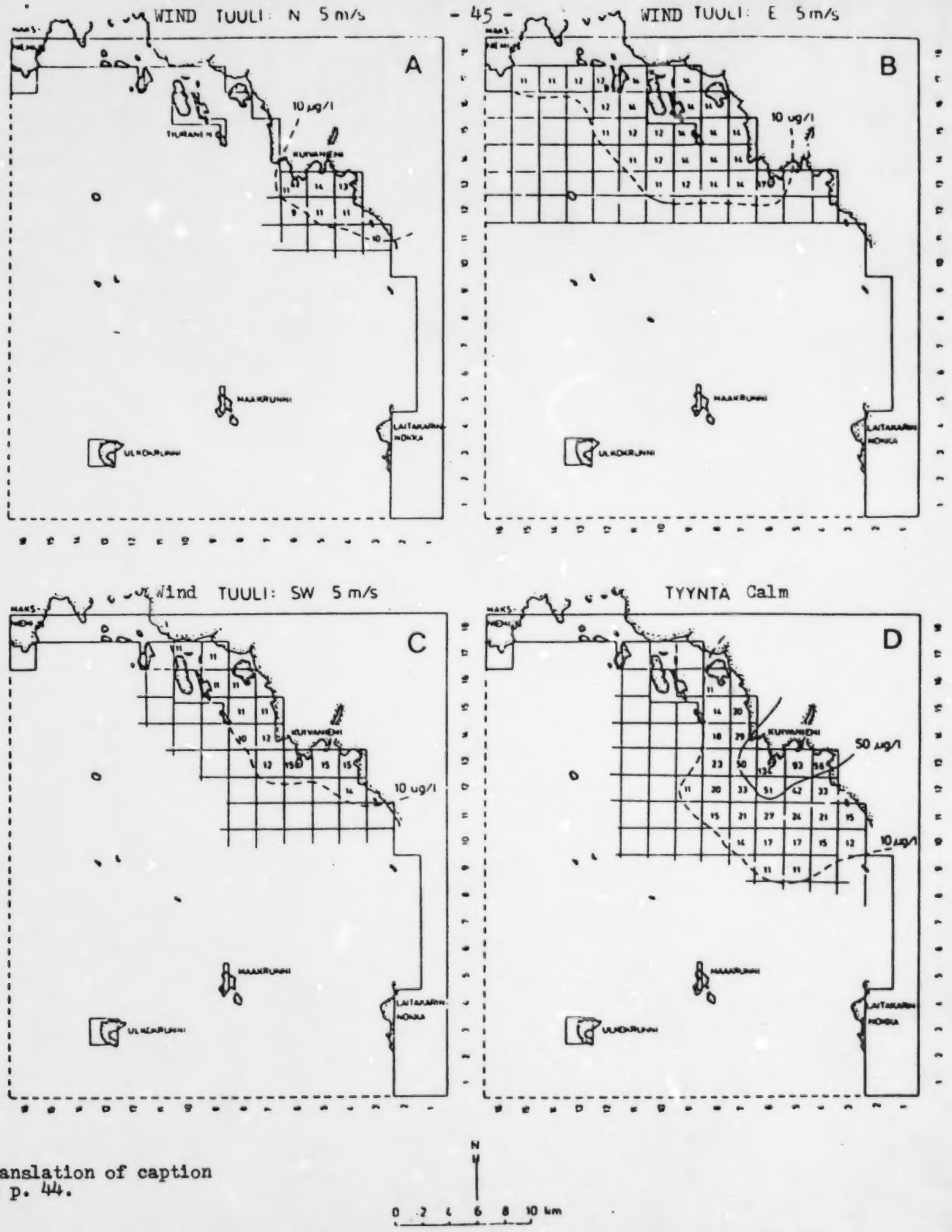
Illustration 11 [on page 45]. Distribution of the total phosphorus content (ug/L) during a northerly wind of 5 m/s (A), an easterly wind of 5 m/s (B), and a southwesterly wind of 5 m/s (C), and during calm weather after a currentless period of 90 days, when the pollution from fish farms is 160 kg P/d (Alasaarela and Salmela 1982).




Translation of caption on p. 44.

Kuva 11. Kokonaisfosforin pitoisuusjakauma (µg/l) pohjoistuulella 5 m/s (A), itätuulella 5 m/s (B) ja lounaistuulella 5 m/s (C) sekä tyynellä säällä 90 vrk:n virtauksettoman jakson jälkeen, kun kalalaitosten kuormitus on 160 kg P/d (Alasaarela ja Salmela 1982).

A good comparison for the situation off Kuivaniemi is the area off Kemi, where strong eutrophication took place in 1969-1970. The pollution of the marine area gave rise to an outbreak of blue-green algae, which resulted in sensory defects in the fish. The 1969 phosphorus pollution of the area off Oulu was about 930 kg P/d and a phosphorus content exceeding 25 µg P/L covered about 140 km² (Myllymaa 1973). In 1976, the pollution of the area was about 170 kg P/d and a phosphorus content exceeding 25 µg P/L covered an area of about 25 km² (Myllymaa 1980). The marine area off Kuivaniemi differs considerably from that off Oulu. 37

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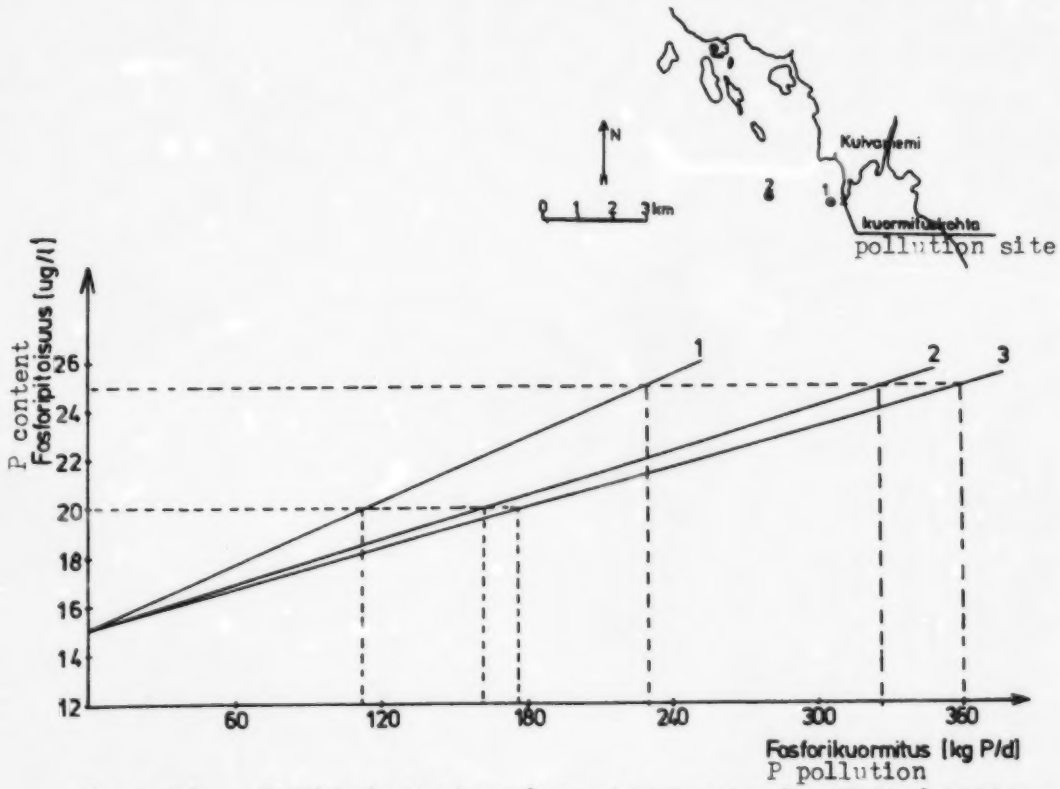
Illustration 12. The dependence of the phosphorus content on pollution in various observation locations. Readings presented by Alasaarela and Salmela (1982) were used as the starting data.




Kuva 12. Fosforipitoisuuden riippuvuus kuormituksesta eri havaintopaikoilla. Lähtötietoina on käytetty Alasaarelan ja Salmelan (1982) esittämiä arvoja.

A regulation of the volume of water in Oulujoki effectively spreads and dilutes the pollution. On the other hand, the area off Oulu consists of protected bays, and marine currents caused by the wind cannot have any great effect. The volume of water in Kuivajoki flowing into the sea off Kuivaniemi is very small in summer. Because the area off Kuivaniemi is open, marine currents caused by the wind help dilute the pollution effectively.

## EUTROPHICATION

Eutrophication means that the primary production of a water system increases. The increase in the primary production is mostly due to an increased amount of plant nutrients in the water. In practice, eutrophication takes place when the increasing nutrition constitutes a so-called minimum factor of the primary production. To know what the pollution tolerance etc. is, it is therefore important to know which factors limit the primary production of phytoplankton. Production in the Gulf of Bothnia is affected by factors such as light, temperature, stratification of the masses of water, nutrients, composition of the phytoplankton communities and physiological condition. It is somewhat misleading to limit one's attention to any individual factor when the complex nature of different environmental effects is known. The dynamics of the process must also be taken into account because the situation of a given moment is also affected by any preceding processes. Due to a better water circulation, marine areas are generally less apt to eutrophy than lakes whose characteristics are otherwise similar. Eutrophication of inland waters brings about changes in the ecosystem that are slow to reverse. This is primarily due to changes taking place in the bottom sedimentation. Water changes quickly in the coastal area. Sedimentation is therefore slow, and changes caused by eutrophication take place more slowly and reversal takes place faster than in inland waters.

Coastal studies show that the minimum-factor question of the marine area is quite complex. As a rule, nitrogen is more important than phosphorus as a factor limiting production in sea waters, while phosphorus is the most important factor limiting primary production in open seas. In the polluted coastal area, the exhausted supply of mineralizing nitrogen usable by plants has a distinct effect, but in late summer, when the secondary effects of eutrophication are most noticeable, the importance of phosphorus is greater than that of nitrogen (Alasaarela 1978). The pollution caused by fish farms in the marine area off Kuivaniemi increases the amount of phosphorus and nitrogen nutrition that can be used by phytoplankton algae. If the nutrient contents of the area exceed a given critical limit, eutrophication will increase to a harmful level. 38

No eutrophication classification indicating phosphorus contents has been produced for our marine areas. According to the eutrophication classification of Dillon (1975), a lake is oligotrophic if its total phosphorus content is less than 10 µg/L and eutrophic if it is higher than 20 µg/L. When the content exceeds 15 µg/L, the eutrophication can already be considered to be clearly detectable. According to the mandatory monitoring results (e.g. Taskila 1984), readings of chlorophyll a and the primary productivity indicating eutrophication have been noted in the marine area off Vatunginnokka already at considerably lower phosphorus contents. Isolated monitoring observations do not give an accurate picture of the interdependencies between the eutrophication level and the water chemistry.

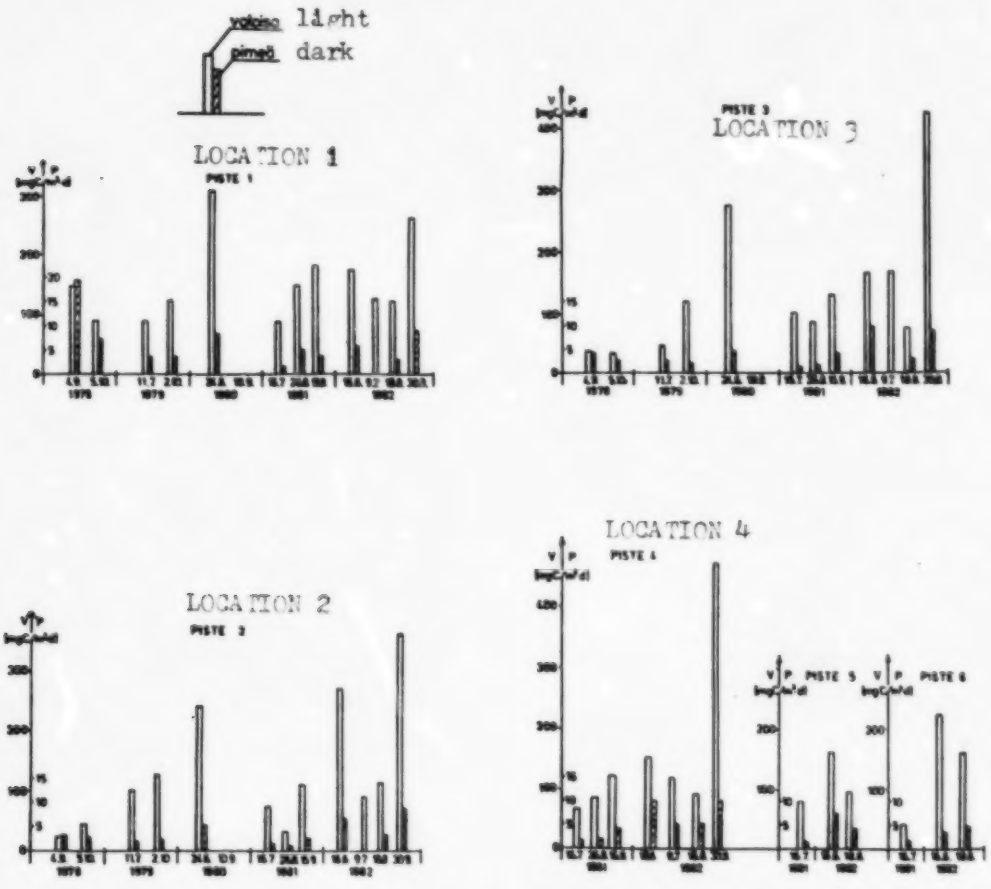
In connection with the mandatory monitoring during the summer, primary productivity was measured in every sample of the surface water. Illustration 13 shows the primary productivity in different observation locations. The temperature is crucially important for the primary

production of early summer. The primary productivity of the calm and warm June 1980 showed distinct eutrophication. Due to poor mixing, the water contained an abundance of unused nutrients, and conditions favourable for eutrophication were therefore in place. Unusually large biomasses of algae were observed in the marine area from Kuivaniemi to Kemi in June 1982 as well. The phenomenon occurred after the cold early summer when the weather suddenly warmed up. The high readings of primary productivity observed at the end of September 1982 were probably due to a storm about a week earlier, which flushed and mixed coastal nutrients into the water system.

The primary productivity readings of 1978 and 1979 indicate eutrophication. Eutrophication was relatively strong in June 1980. Nutrient contents were fairly high in late summer 1980. However, no primary productivity readings are available for this period. The primary productivity readings of summer 1982 show considerable eutrophication. The primary productivity readings of observation locations 1, 2 and 6 were clearly higher than those of location 4, which is situated on the seaward side of Kuivamatala. The 1979 readings of primary production were just 6-13 mg C/m³/d in the outer marine area and in October 1980, the readings were 150-170 mg C/m³/d. The chlorophyll contents observed in the area indicate average eutrophication.

Severe sliming was observed in the vicinity of Lapplax Ltd. in late summer 1982. The sliming was most severe in location 2 which is situated between Kuivamatala and the mainland (Appendix 3). Algae growing on bottom rocks, higher vegetation, fishing gear, etc. are not removed by water circulation. 39

Illustration 13. Primary productivity and carbon fixation in the dark in mandatory monitoring locations in the vicinity of Vatunginnokka in 1978-1982 (see Illustration 7).




Kuva 13. Perustuotantokyky ja hiilen pimeäsitoutuminen vuosina 1978 - 1982 Vatunginnokan lähistön velvoitetarkkailupaikoissa (katso kuva 7).

# 5 PROBLEMS AND OBJECTIVES OF WATER POLLUTION CONTROL

Fish farming takes place during the summer season and the planning area does not have any deep spots; consequently, the oxygen situation of late winter should not be a problem. The most distinct and harmful effect of fish farming off Kuivaniemi as elsewhere is a rise in the nutrient content of the water. The harmful effects of the increasing nutrient content include fouling of fishing implements, clouding by algae and sliminess of the bottom. The fouling of fishing implements means smaller catches and more work for the fishermen when they have to clean their implements. According to observations made in the Turku archipelago, 40
the operations of rainbow trout facilities situated in marine straits may scare off schools of Baltic herring and prevent them from coming to their spawning grounds. This has manifested in phenomena such as a catastrophic drop in the catches of fyke fishing on the spawning grounds. If the fishing is made impossible or difficult, the water area will experience reduced yields. Clouding by algae and sliminess of the bottom in coastal areas will reduce their recreational value. If the hygienic condition of the water deteriorates, the vicinity of fish farms is made less suitable for swimming. Problems have also been experienced in the siting control of facilities intent on locating in the area. A lack of tested and functional solutions suitable for the water pollution control of the marine area also presents problems.

The general objective of water pollution control is to reduce any harmful effects manifesting in the water system and the final goal is to eliminate such effects. The necessary pollution control measures cannot, however, be determined on the basis of the water system alone, but water pollution control constitutes an entity, which is affected by water pollution control problems, their magnitude and significance, available technology, costs, etc. When establishing the objectives of the plan,

the starting point was the condition, usability and actual use of the water system, and effects of the fouling. Accordingly, the objective of the plan was to present recommendations on how the pollution caused by the present facilities can be reduced and how many and where in the planning area new facilities intent on locating there can be sited. Siting control must take into account water pollution caused by fish farming and related experience gained in the planning area so far, possibilities of reducing pollution, harmful effects manifesting in the vicinity of facilities in particular, other uses of the water and siting requirements of the facilities. Even after the expansions, increasing fish farming must thus accomodate other uses of the water system and it must not impair

- the recreational usability of the area and the conservation value of islands to be conserved.

- the condition and suitability of the water for system commercial, household and recreational fishing, nor the procreation and migration of the natural fish stocks of the area.

- the suitability of the coastal areas for vacation housing and tourist operations.

6 DEVELOPMENT POSSIBILITIES OF WATER POLLUTION CONTROL 41

## 6.1 MEANS OF REDUCING WATER POLLUTION FROM FISH FARMING

The pollution caused by fish farms can be thought to consist mainly of excrement which is both solid and liquid, and to a minor degree of waste

feed. If the intention is to collect the excrement sludge, it must first be allowed to settle and then be removed from the cage. The settling rate of fresh, undecomposed excrement is relatively good. However, the rapid dissolution of nutrients in the water and the rapid weakening of the settling properties of aging sludge pose a problem. When reducing the wastewater pollution of facilities, attention should primarily be paid to the removal of nutrients, development of feed and the feeding technique, and partially breeding of stocks. Sludge removal methods suitable for net cages are limited in number, (sludge fences*, sludge collection bags*), but several methods are being developed.

The preliminary report of Kurkela (1983) presents in more detail the main principles of pollution reduction and introduces different ideas and solutions, of which a few have also been tested in practice.

## 6.2 ESTIMATING THE PERMISSIBLE EXTENT OF FISH FARMING AND SITE CONTROL

### 6.2.1 Estimating the range of the harmful impact of fish farming

On the basis of Illustrations 11 and 12, the impact area of fish farming can be estimated as shown in Illustration 14. The drawing was made by estimating the surface of an area carrying a phosphorus content exceeding 20-25 µg P/L. The drawing also shows the impact area of Lapplax Ltd., estimated by Myllymaa (1982). Myllymaa's estimate is mainly based on studies carried out on the impact of the operations of the facility to date and partially on results obtained by the VENLA model. In addition to the nutrient pollution, the estimate also examines the impact of the operations on the hygienic condition of the water area.

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*Literal translation. Translator's note.

The impact range of a fish farm producing 100 t/a (11.7 kg P/d) can thus be estimated to be under 2 km². The impact range of a facility producing 500 t/a (58.3 kg P/d) is under 10 km² and that of a facility producing 1000 t/a (116.7 kg P/d) under 20 km². The impact cannot be estimated on the basis of observations carried out according to the VENLA model only. A water quality prediction helps create a general idea of the effect the pollution has on the phosphorus contents of the planning area. An effort was also made to take into account any impact on the vicinity of the fish farm, when the siting possibilities of fish farms in different parts of the planning area were assessed.

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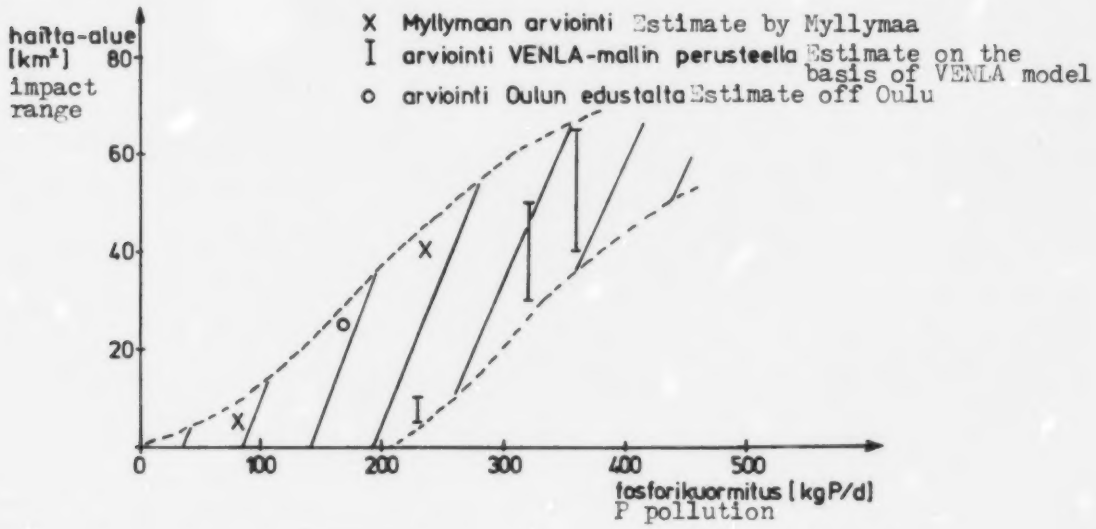
Illustration 14. Dependence of the impact range (km²) of a fish farm on the phosphorus pollution of the farm (kg P/d).




Kuva 14. Kalankasvatuslaitoksen haitta-alueen ($km^2$) riippuvuus laitoksen fosforikuormituksesta (kg P/d).

More information would be gained for the purpose of estimating the extent of fish farming in the planning area if a supplementary study examining the phosphorus content of the area was carried out, using the VENLA water-quality prediction model. The study would differ considerably from a model run already done in the area. The planning area should be divided into a denser grid (1 x 1 km) so that the impact range of an individual facility could be accurately determined. Wind information from the relatively calm summer of 1980 could be fed into the computer run. The phosphorus contents of the area would be determined by means of different pollution alternatives. The phosphorus pollution levels of fish farms would be the actual levels of the production period. The summertime phosphorus discharges of wells during the summer are obtained on the basis of discharges and average phosphorus contents. The starting phosphorus contents of the area can be estimated on the basis of river water percentages. The model could print the results of several critical situations from the production period and it could be determined on that basis which polluters most affected the situation. 42

### 6.2.2 Requirements regarding fish farming sites

The most important characteristics of the water in terms of fish farming are temperature, oxygen content, acidity and possible impurities. The oxygen content, acidity or impurities do not limit fish farming operations in the planning area. The temperature of the surface water may rise to more than 22°C in the shallow coastal areas during summertime hot spells. It is for this reason advantageous to place the net cages in spots that are more than six meters deep.

A water current speed of 3-10 meters per minute is favourable for fish farming. Good current conditions in a fish farm help dilute the nutrients quickly. On the other hand, effective water circulation may be an impediment to the development of water pollution control measures. In the planning area, the best sites for fish farms in terms of water current conditions are points of land and shores of islands in the marine area. Water current conditions are poor in coastal coves and in the lee of the islands. In poor water current conditions, the bottom close to a net cage may collect so much sludge that it even hampers the rearing operations themselves (e.g. methane fermentation). In theory, the present Lapplax operations of about 400 t would produce a sludge layer of about 1-3 cm/year on the bottom of a rearing cage. On the basis of the analysis results (Table 11), however, no clear-cut trend can be noticed in the phosphorus content of the bottom sludge or the quantity of organic matter. The average nitrogen content of the sediment rose in 1978-1980 but in the analyses of 1981, the nitrogen content remained below the analysis sensitivity. The average phosphorus content of the sediment also rose in 1978-1980 but the phosphorus content of 1981 was lower. 43

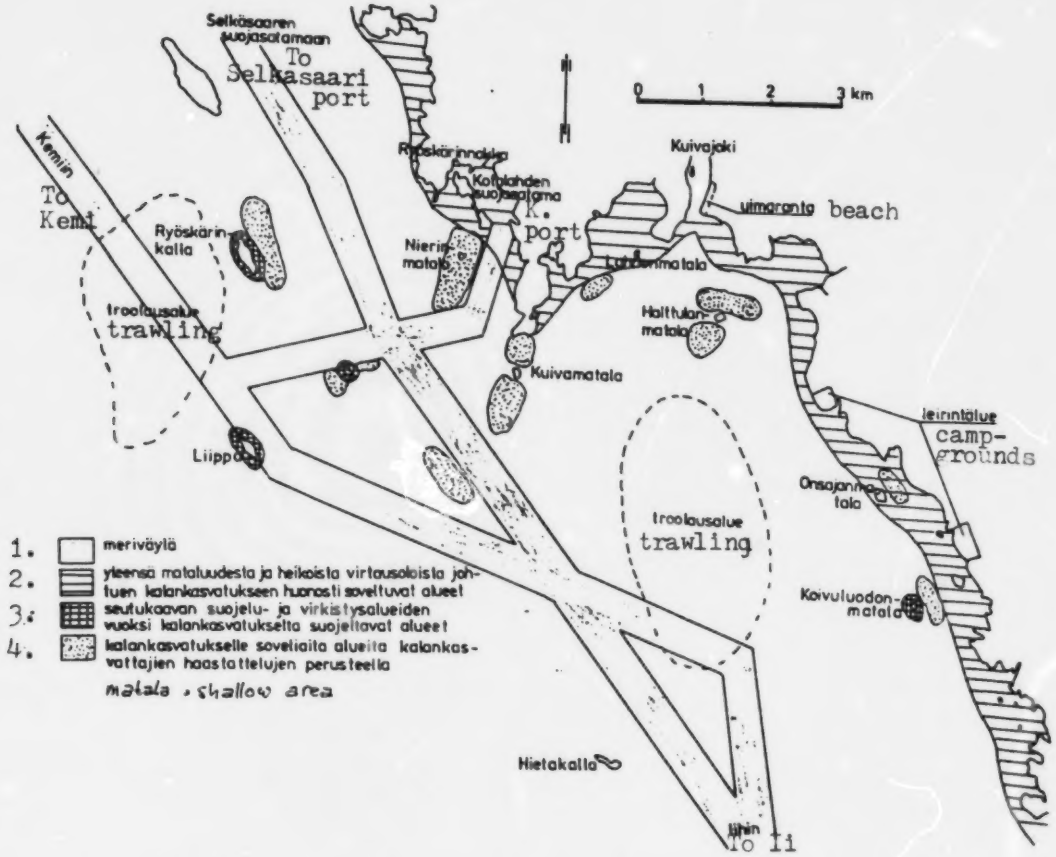
When looking for suitable fish farming sites in the planning area, a survey was conducted among area fish farmers asking about areas suited for fish farming. The crucial factor affecting the choice of a fish farming site was overly heavy seas. Heavy seas may bring driftwood which can break the net cages. Illustration 15 shows areas suitable for fish farming. 44

Table 11. Analysis results on the bottom sediment in the vicinity of Vatunginnokka during 1978-1982 in Kuivaniemi.

Taulukko 11. Pohjasedimenttitulokset Vatunginnokan läheisyydessä vuosina 1978 - 1982 Kuivaniemellä.

| Sampling location<br>Näytepiste | Dry matter<br>Kuiva-aine<br>% | Ignition residue<br>Hehkutus-jäännös<br>% | Total P<br>Kok.P<br>mg/g | Total N<br>Kok.N<br>mg/g |
|---|---|---|---|---|
| 4.9.1978 | | | | |
| P 1 | 69 | 99 | 0,32 | 0,15 |
| P 2 | 31 | 92 | 0,59 | 0,67 |
| P 3 | 71 | 98 | 0,54 | 0,30 |
| 5.10.1978 | | | | |
| P 2 | 37 | 96 | 0,56 | 0,76 |
| P 3 | 41 | 96 | 0,54 | 0,65 |
| 2.10.1979 | | | | |
| P 1 | 78 | 99 | 0,65 | 0,16 |
| P 2 | 44 | 96 | 0,78 | 0,81 |
| P 3 | 68 | 99 | 0,48 | 0,33 |
| 24.6.1980 | | | | |
| P 1 | 60 | 97,5 | 0,73 | 0,58 |
| P 2 | 50 | 96,6 | 0.56 | 0.56 |
| P 3 | 26 | 90,9 | 0,96 | 1,80 |
| 16.7.1981 | | | | |
| P 2 | 69 | 98,5 | 0,47 | <0,05 |
| P 3 | 65 | 98,4 | 0,65 | <0,05 |
| P 4 | 74 | 98,7 | 0,53 | <0,05 |

Illustration 15. Main uses of the planning area.




Kuva 15. Suunnittelualueen pääpiirteittäiset käyttömuodot.

1) shipping channel
2) areas poorly suited for fish farming generally because of shallowness and weak water current conditions
3) no fish farming in these areas marked for conservation and recreation in the regional plan
4) areas deemed suitable for fish farming on the basis of interviews with fish farmers

### 6.2.3 Keeping in mind other uses of the water system

It is probably not possible to establish fish farms in the marine area off Kuivaniemi near coastal housing without any harmful impact. The same applies to waters close to recreational and backpacking areas. The recreational value of the shore is reduced because of the eutrophication and the deterioration of the hygienic condition caused by fish farming.

The shipping channels running through the area off Kuivaniemi should also be protected from fish farming. Rafts of timber are floated in the shipping channels. Strong wind may push a raft hundreds of meters off the channel. The planning area also contains the ports of Kotalahti and Selkasaari and their incoming channels which are covered by the floating regulations of the Gulf of Bothnia. The boats of the fishing port of Vatunginnokka and boating by small craft restrict the site selection of fish farming to some extent. 45

The islands of the marine area of Kuivaniemi and Olhava are conservation areas under the regional plan. They are showed as natural environment forests in the regional plan. Places such as Ryoskarinkalla, Samulinmatala, Rintamatala and Liippa are in an area of the regional plan that has been singled out for conservation. It is not appropriate to place fish farming in the immediate vicinity of islands because the impact of fish farming would show as fouling of beaches and as rearing structures, which is in conflict with the above conservation use (Verbal comm., October 82, Regional Planning Authority, chief regional planner J. Ravaska, and County Administration, environmental inspector E. Kaakinen). Koivuluodonmatala, Rynkynletto and Kokkosaari are also natural environment forests of the National Forest Administration and the regional plan shows them as recreational areas, where outdoors

activities do not require considerable construction. The area in question is meant to be a support area of the Rynkylehto campground on the coast. It is therefore thought that fish farming is not appropriate in the immediate vicinity of Koivuluodonmatala because it is in conflict with the recreational use (Verbal comm., November 82, Regional Planning Authority, J. Ravaska, and County Administration, E. Kaakinen).

Appendix 4 shows the most important fishing locations off Kuivaniemi. The impact of fish farming is greatest on fyke and net fishing. In the immediate vicinity of a fish farm, the sliming of fykes may be so severe that the fyke location is no longer suitable for fishing. The best period for fyke fishing is June-July. There are 20 fyke lines owned by the state and 27 owned by the local fishery association in the area. The fyke lines of the state are about 500-900 m long and their locations are the same from year to year. The fyke lines of the fishery association are about 50-500 m long and their locations may vary to some extent. Net fishing is carried out in the area mostly as supplementary and hobby fishing. The nets may get very slimy in the vicinity of a fish farm. The most important trawling areas are further out in the open sea.

### 6.2.4 Limitations and possibilities of fish farming by subarea

The following will estimate the permissible volume of fish farming in different subareas of the planning area (Illustration 16), taking into account suitability of the areas for fish farming, effects of pollution on the condition of the marine area and other uses of the area. Another condition is that the marine area be controllable, for instance through a lease.

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I Vatunginnokka area 46

It is possible to produce 500 t/a of fish in the Vatunginnokka area under the current licences. Lapplax Ltd. also has a permission to store 1,500 t/a over the winter. The quantity reared has varied between 150 and 400 t/a (see Table 4). Interest has been expressed to increase fish farming to 1,350 tonnes annually in the area. The Water Rights Court is currently processing a licence application by Lapplax Ltd. for 900 t/a to be added to its current licence of 400 tonnes. During an inspection,

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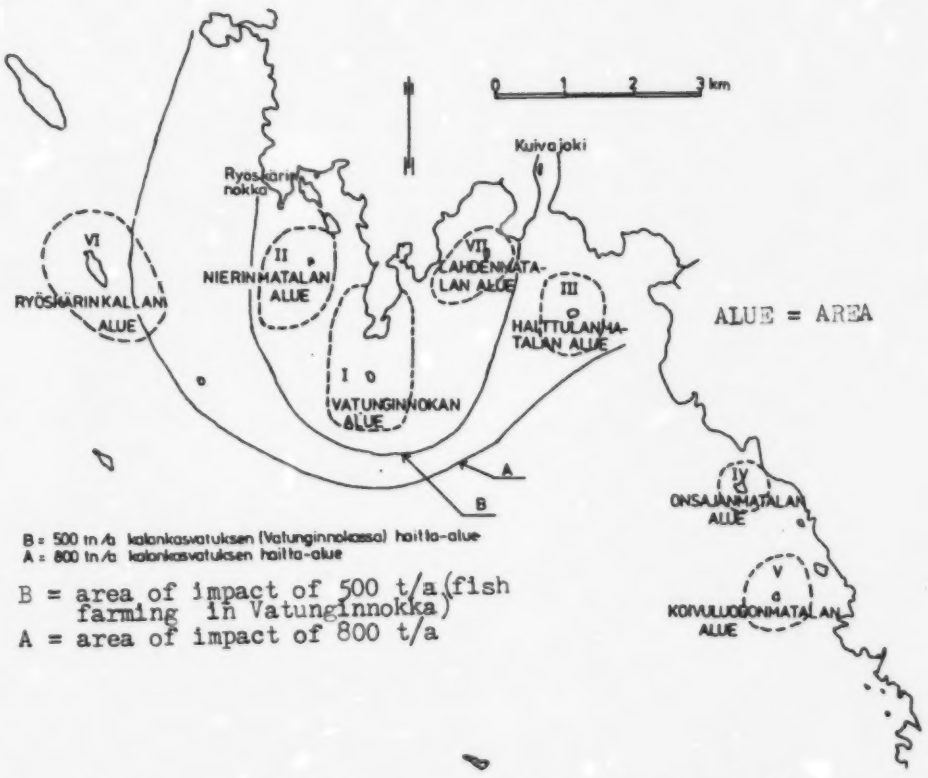
Illustration 16. Division of the planning area into subareas.




Kuva 16. Suunnittelualueen jako osa-alueisiin.

officials suggested a licence for an additional 300 t/a. An inspection statement by Myllymaki (1982) estimates that the impact area of the current culture of 500 t/a (400 t/a by Lapplax + 100 t/a by Perameren Lohi) extends from the mouth of Kuivajoki to Ryoskarinnokka (Ill. 16). Fish culture of 800 t/a (400 t/a + 300 t/a by Lapplax + 100 t/a by Perameren Lohi) at Vatunginnokka would create an area of impact extending from Halttulanmatala to the border between Kuivaniemi and the municipality of Simo (Ill. 16).

The 1983 mandatory monitoring reports on fish farms off Kuivaniemi show (Taskila 1984) that the marine area surrounding Vatunginnokka experienced eutrophication in summer 1983. The highest readings were measured in August when the primary productivity varied between 442 and 718 mg C/m³ and the chlorophyll a content between 8.7 and 11.8 µg/L in the observation locations (see Ill. 7). The readings of the primary productivity and the chlorophyll a contents were higher than those of the previous years in all observation locations, although eutrophication had been present earlier as well. The high readings clearly reflect the sensitivity of the coastal area in crisis situations. According to a draft copy of a recreational suitability classification prepared by the National Water Administration, the area dropped one grade in suitability, i.e. from good to satisfactory. The fish production of the Vatunginnokka area was about 300 tonnes in 1983. 47

A production of 800 tonnes would reduce the recreational value of the shore considerably in Area B (Myllymaa 1982). Within a 1.5 km radius from fish farms, smell and noise impacts are present in addition to the eutrophication impact. According to Myllymaa (1982) and Keranen (1983), pollution caused by the production in question would be felt as increased sliming of stationary nets and fykes, particularly toward late summer in August-September, during the most important fishing season for

fish that spawn in the fall. Area B has 23 fyke fishing locations, and an additional culture of 300 tonnes would make the area unsuitable for fishing that uses stationary fishing gear in late summer. The entire impact area of 800 tonnes includes 37 fyke fishing locations.

As indicated above, the current fish farming alone causes eutrophication in the Vatunginnokka area. Even the current pollution load should therefore be reduced. The Water Division indicated in its statement that a final inspection should be done simultaneously in Lapplax Ltd. and Perameren Lohi. The impact and damage and how to reduce them can be appropriately discussed at the time of the said final inspection. If the production of Lapplax Ltd. grows to the 700 tonnes suggested by the inspectors, Area B will experience an impact that should be compensated for, as the inspectors also suggested. The pollution of the subarea of Vatunginnokka would thus prevent the establishment of new facilities.

II Nierinmatala area

A total of 26 tonnes of rainbow trout (Table 4) was produced in the Nierinmatala area in summer 1983. On the basis of an interview survey, there is interest in the area to increase fish farming production to about 80 tonnes. Pollution caused by the current production of Vatunginnokka facilities already reaches this area. The water analyses of observation location P6 indicate (Taskila 1984) that the Nierinmatala subarea was eutrophic for instance during the summer of 1983. Housing is being planned and already now exists on the islands and shores of Iso and Pikku Paskaletto. If the fish production of Lapplax increases to 700 tonnes, the pollution of the Nierinmatala marine area will rise and no increase in fish farming operations can be accomodated. Since a harmful impact is felt, an application must be submitted to and a licence obtained from the Water Rights Court to continue operations of

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the current magnitude as well. Licencing matters should not be handled as individual cases but the applications must be considered with the total impact in mind. The application matters of Nierinmatala facilities could thus be considered simultaneously with the possible final inspection of Lapplax and Perameren Lohi.

III Halttulanmatala area

About 13 tonnes of rainbow trout was reared in the vicinity of Halttulanmatala in summer 1983. Two small rainbow trout facilities are located in the area. The maximum production of the Risto Rousu facility licenced by the Water Rights Court is 20 t/a. Summertime water current conditions are likely to be fairly poor because the area is situated in a relatively sheltered and shallow bay. The pollution impact of the present production of Vatunginnokka fish farms is not likely to reach this area. If the production of Vatunginnokka facilities increases, the impact is likely to be felt in the Halttulanmatala area as well when the winds are favourable. A mandatory monitoring in August 1983 showed slight eutrophication (chlorophyll 6.8 µg/L). In addition to fish farms, the waters of Kuivajoki affect the eutrophication level. The area near the shore is fairly densely populated. The Kaakkurinniemi campground is situated about 2 km away. Several fyke lines lie between Halttulanmatala and the mainland. The island of Halttulanmatala has been set aside for recreational use in the draft general plan covering the Kuivaniemi coast. Any future possibilities to increase fish farming in the area can be assessed only after the effects of operations of the current magnitude have been observed for some time.

IV Onsajanmatala area

According to the interview survey, there is interest in fish farming on the landward side of Onsajanmatala (Ill. 15). The Onsajanmatala area is situated fairly close to the shore and the area is shallow. There is a lot of coastal housing in the vicinity and the campgrounds of Kaakkuriniemi and Rynkynletto are situated about 1.5-2 km away. A tourist hotel near Onsajanmatala is also in the plans. To establish a fish farm and to operate in this area would appear to be in conflict with other uses of the marine area. It is, however, probably possible to carry on fish farming for an annual total of up to a few thousand kg without any harmful impact if the Allotment Area rents a marine area needed for such an operation.

V Koivuluodonmatala 49

Interest has been expressed in fish farming for about 140 t/a in the Koivuluodonmatala area. In the regional plan, the island of Koivuluodonmatala has been specified as a recreational area that does not require considerable construction for outdoors activities. The area in question is meant to be a support area for the Rynkynletto campground. It is therefore thought that fish farming in the immediate vicinity of Koivuluodonmatala is in conflict with the recreational use proposed in the regional plan. A total of 20 t/a of fish cultured in 2 or 3 facilities that are sufficiently far from each other and at least 200 m from the island is probably the combined maximum that can be cultured in this area without any harmful impact. It can be assessed if conditions for a greater fish farming volume are met after a water quality prediction is prepared for the subarea and circumstances affecting the matter have emerged in the Water Rights Court handling.

VI Ryoskarinkalla

Interest has been expressed in fish farming for about 320 t/a in the vicinity of Ryoskarinkalla. The regional plan shows places such as Ryoskarinkalla, Samulinmatala, Rintamatala and Liippa as parts of an area that has been singled out for conservation and that is to stay in the natural state. The erection of structures for extensive fish farming in places such as Ryoskarinkalla or its immediate vicinity would therefore be in conflict with the intended uses of the island. It may be possible to produce fish without a Water Rights Court licence at a minimum distance of about 200 m from the island, for a maximum total of 50 t/a, if the operations are not in conflict with island conservation. The operations should not, however, be situated in any one place. If any harmful impact becomes apparent, an application regarding the operations must be submitted to and a licence obtained from the Water Rights Court. After operational experience has been gained, expanded fish production under a Water Rights Court licence could later be considered. Extensive fish farming may be prevented by limitations posed by island conservation. As far as water pollution control is concerned, however, it is possible to aim at utilizing the full fish farming capacity of the area right from the start. This requires, however, a thorough study of its environmental impact. As to the impact on the water system, a water quality prediction based on different pollution alternatives should be prepared for the area. It would be appropriate for all the facilities of the area to apply for a Water Rights Court licence simultaneously.

VII Lahdenmatala and Eskonmatala area

The landward side of Lahdenmatala is situated at the mouth of a highly protected and shallow bay. The coastal area has many cottages. Eskonmatala is also near coastal housing. The impact of Vatunginnokka fish farms is already today apparent in this area. The area should therefore not be subjected to increased pollution.

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Other areas

Due to shallowness and poor water currents, areas close to the shore (Ill. 15) are generally unsuitable or marginal for fish farming. Due to coastal housing, recreational use, etc., it is generally not possible to establish fish farms near the shore (for instance 500 m from the shoreline). Fish farming in small units may, however, be possible in areas such as Onsajanmatala, which is within the coastal area. Good water currents further out in the marine area create better conditions for fish farming. The survey found, however, that there was no interest in fish farming in the open sea which lacks shelter given by islands. The use of shipping channels, trawling grounds and fyke locations must, however, be protected.

## 6.3 IMPROVING CONTROL, MONITORING AND RESEARCH

A Water Rights Court licence is always needed if the construction and operation of a fish farm alters, blocks or fouls the water system (VL 1:12-15 or 1:19). It is not possible to determine any unambiguous facility size that would require an application for licence. The licencing situation of the area off Kuivaniemi is shown in Table 3. The Water Division has given statements on fish farming notices received and explained when a facility must apply for a licence from the Water Rights Court. If several facilities intended to locate in one and the same area, their combined impact was taken into account when licencing needs were considered.

The monitoring of fish farming includes monitoring of use and care, pollution monitoring and monitoring of the water system. The mandatory monitoring is a means of following the amount of water intake, the use

and care of the facility, the amount and quality of waste water and its impact on the recipient water system. No pollution monitoring is carried out in net cage facilities. Their pollution is estimated on the basis of the quantity of feed used and the fish produced. In water system monitoring, attention is paid measurements and methods expressing eutrophication. The area off Vatunginnokka has seven sampling locations (see Ill. 7) and the area off Halttulanmatala one sampling location. In the sampling locations off Vatunginnokka, water samples are taken four times during the open-water season, i.e. in June, July, August and September, and twice during the winter, i.e. in November-December and March-April. The water quality of the sampling location in Halttulan-matala is examined once a year (August).

Conditions in the marine area fluctuate considerably more than in the inland water areas. The mandatory monitoring of fish farms consequently reveals great differences from one sampling occasion to the other. A sufficiently frequent sampling is therefore necessary so that a sufficiently clear picture of the water system can be formed during critical situations. Sampling locations off Kuivaniemi should be established further away from a polluter, particularly near coastal housing, beaches and campgrounds as well as in the deep spots of the area. Even relatively shallow hollows of the planning area may collect organic matter that can lead to a drop in the oxygen content and a rise in the nutrient content of the bottom water. When fish farming expands, monitoring should also be carried out in hollows situated at 65° 32,7′ N and 25° 04,5′ E and 65° 31,5′ N, 25° 08,5′ E. The water depth exceeds 10 m in these places.

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Studies on bottom organisms (periphyton) using artificial bottoms can clarify the impact of algae organisms on the fishing economy and other uses of the area. Changes in the state of the water system can be

detected sufficiently early if periphyton studies are carried out every summer. The results are useful for instance when assessing the impact on fishing. The sliming of nets can be examined with netting experiments as well. The condition of the shore and the bottom in the vicinity of fish farms could be examined by diving. Studies on the bottom fauna could give valuable information on the intensity and extent of eutrophication in the area. An effort should be made to study changes in the fish stocks, disappearance of fish, drop in the catch potential of fishing grounds such as fyke lines, and changes that have taken and are taking p e in quantities of catch in the area.

It is very difficult to estimate the amount of fish in cages. The capacities and water circulation of net cages are in most cases sufficient for a fish production considerably in excess of the licence. It is to some extent possible to control the quantity reared by the size of the net cages. The fish density of net cages can at its maximum be as high as 25 kg/m3. A fish density of 10-15 kg/m³ would be sufficient to justify fish farming. The licences of fish farms could therefore include a condition on cage size. To control quantities of fish, the fish farmer could also be obligated to submit a valid proof of the quantity of fish reared (e.g. proof of insurance or tax). A lot of fish comes on the market in the fall when it reaches the slaughter size. Large facilities must for this reason store fish in storage cages in winter. A lack of winter storage cages that withstand marine conditions has necessitated a transfer of fish from the planning area to inland facilities. This has in some cases caused a harmful impact on the water system. Fish 52
farms should explain at the time of licencing procedures how winter storage is to be arranged.

Because no adequate method to reduce pollution has been developed for net cages yet, a water pollution control surcharge under section 10(27) of the Water Rights Law can be applied to expenses incurred in reserach

involving the environmental impact of fish farming. The Water Rights Law specifies that when an individual, corporation or community is granted a licence to discharge waste water into a water system on conditions that completely or partially exempt the licencee from water pollution control measures or when the licence helps the licencee obtain considerable operational savings or other considerable financial benefit, the licencee can be placed under an obligation to pay an annual water pollution control surcharge to the state. The underlying objective of this surcharge is thus to "tax" the true benefit that the facility enjoys because it does not have to invest in water pollution control and saves in operational costs, etc. It is difficult to determine this true benefit and in part it has to be established by means of separate studies. Kurkela (1984) tentatively looked into criteria applying to the surcharge. The Water Administration should define the criteria and the size of the surcharge nationally.

## 7 RECOMMENDED MEASURES

### Recommendations regarding expansion of fish farming

Fish farming in the marine area off Kuivaniemi is already in its current magnitude a considerable polluter of the water system. Fish farming operations are undergoing vigorous expansion. Consequently, the plan explains to what extent and toward which area fish farming can be steered.

The fish farming potential and volume depends principally on the water circulation of the farming location, on the condition of the surrounding water area and possibly on the location of other facilities in the area as well as the site of a planned station with respect to other uses of the water area. Fish farming expansion must proceed carefully while its effects on the water environment are monitored.

The fish farms of the Vatunginnokka subarea have caused a harmful impact due to eutrophication. The harmful impact, damage and their reduction should be discussed for instance in connection with a final inspection carried out simultaneously in all facilities. An expansion in fish farming would result in more water pollution, which must be taken into consideration when new licence applications are processed.

The pollution impact of the current production of Vatunginnokka facilities already extends to the Nierinmatala area to the northeast. Because eutrophication is present, the Nierinmatala facilities must apply for a Water Rights Court licence to operate. The licencing matters of Nierinmatala facilities should all be processed at the same time, keeping in mind the pollution effects of the Vatunginnokka facilities and associated measures under the water rights legislation. 53

Because of its location and water current conditions, the Lahdenmatala area is not very suitable for fish farming operations. Because Lahdenmatala is also situated within the impact area of the Vatunginnokka facilities, no fish farms should be located there.

The location of Halttulanmatala with respect to housing, fishing grounds and recreational use may prevent any expansion of the current operations. Any expansion can be considered only after sufficient experience has been gained from the current fish farming.

Onsajanmatala does not meet the requirements set on extensive fish farming operations. The potential harmful impact of operations is, however, minor if fish production is kept to a few thousand kilograms a year. Fish production should be carefully expanded beyound this amount only if the experience gained is positive.

The regional plan sets Koivuluodonmatala aside as a recreational area. It may be possible to produce fish in Koivuluodonmatala in 2-3 facilities that are sufficiently far from each other, at least 200 m from the island and at least 500 m from the shore, for a total of 20 t/a, without any eutrophication impact. If the operations expand beyond this amount, the potential of eutrophication and other impact on the environment would increase. Expansion beyond the above production should be considered only after a thorough study has been carried out on any marine and other environmental effects.

The regional plan reserves the islands of the Ryoskarinkalla area as conservation areas, which are to be kept in the natural state. When the site of fish farming operations is being considered, the Water Administration should as the owner of the marine area and the islands ascertain that the operations do not jeopardize the conservation objectives of the islands. The facilities should be located at least 200 m from the islands. If island conservation is not any obstacle, the farming operations could possibly be carefully expanded up to a maximum total of 50 tonnes a year. Expansion beyond this amount should be considered only after a thorough study has been carried out on any marine and other environmental effects.

No submissions have so far been made to establish facilities in open areas far away from the shore and the lee of the islands. In terms of water pollution control, on a case to case basis, it is possible to establish facilities in the open sea as well. The pollution caused by the facilities requires, however, that fish farming without a Water Rights Court licence is limited to a maximum of 50 tonnes a year, even in the best locations in terms of water pollution control. In addition to the pollution effects, trawling grounds, fyke locations and shipping channels should also be taken into account already when the sites of facilities are being planned. 54

With the exception of Vatunginnokka, areas close to the shore are generally unsuitable or marginal for fish farming because of their shallowness and poor water current conditions. It is generally not possible to establish fish farms in these areas without any harmful impact on the recreational use of the near-by area in particular. A very critical look must therefore be taken on facilities that want to establish in the vicinity of the shore.

The National Water Administration must continue to assess the marine effects and particularly the operational expansion possibilities of fish farms in the sea off Kuivaniemi with model studies geared to each subarea. The water quality in different parts of the planning area should be determined as needed for forecasting purposes.

Recommendations regarding pollution reduction

In feeding, use should be made of so-called environment-friendly dry feeds which cause as little pollution as possible.

Feed dust should be sieved out of the dry feed before feeding. Feeding should be carried out so that no dust is formed. Enough time must be set aside for feeding and the feed should be spread evenly, avoiding overfeeding.

Wet feed should be avoided. However, if wet feed must be used, the feed should be solidly pelleted to reduce waste.

An efficient and sufficiently rapid sludge removal method should be organized for eathern ponds. The sludge should be treated when it is still fresh. Sludge removal systems suitable for marine conditions

should be adopted for net cages. The removed sludge should be treated in an appropriate manner using methods such as peat filtering.

Because no sufficiently efficient methods for pollution reduction have been developed for net cages so far, the facilities should be levied a water pollution control surcharge. The Water Administration should quickly define the criteria and the size of the surcharge. However, no surcharge should be levied on small facilities.

Recommendations regarding control measures 55

Notices of all fish farming projects should be submitted to the Water Division of the Water District of Oulu already at the planning stage. It is assessed on the basis of the notice whether a licence by the Water Rights Court is required.

The Act on Water Pollution Prevention (283/63) should be amended so that fish farms are added to the list of facilities in section 3.

The Water Rights Court licences should be for a fixed term. Any applicable parts of the terms should coincide so that new applications can be handled together.

Monitoring of the pollution and the water system of the area off Kuivaniemi should be continued as joint monitoring.

The Game and Fishing Research Institute and the National Veterinary Institute should expand the monitoring of fish diseases and their spreading.

The Association of Finnish Salmon Culturists and water authorities should accumulate know-how and solutions pertaining to marine aquaculture and associated water pollution control. This information should be disseminated at events such as joint briefings.

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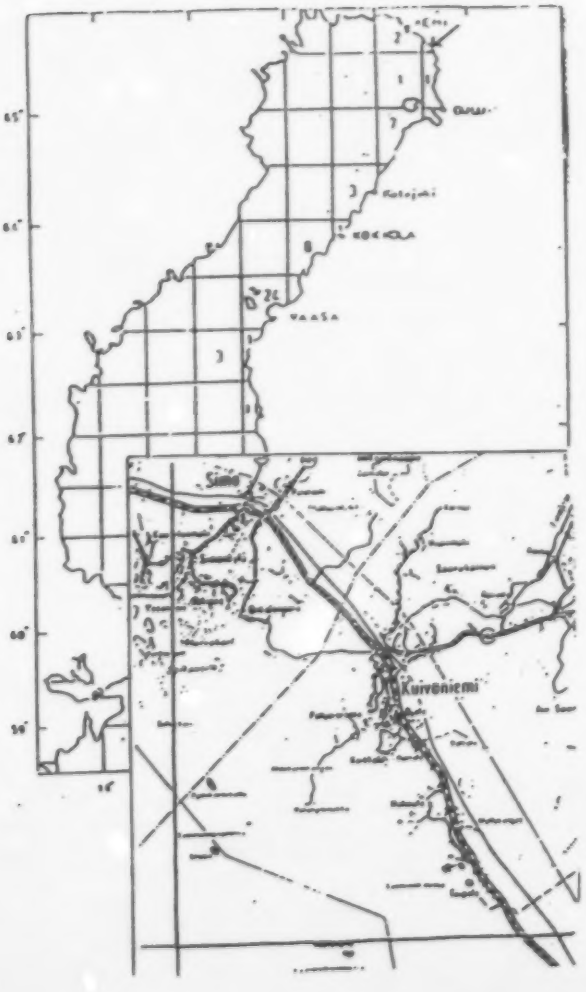
**LIITE 1**
APPENDIX 1

**Kuivaniemen edustan merialueen tärkeimmät kalansaaliit vuonna 1980 (suull. ilm. 15.8.1982 RKTL). Saaliit on saatu alla esitetystä tilastoruudusta**

| Species<br>Kalalajit | Commercial f.<br>Ammattikalastus | Household fishing<br>Kotitarvekalastus | |
|---|---|---|---|
| Silakka | 154 t /a | | Baltic herring |
| Maiva | 21,5 " | 0,5 t /a | Vendace |
| Siika | 9,0 " | 2,5 " | Powan |
| Lohi | 1,8 " | | Salmon |
| Hauki | 0,6 " | 5,0 " | Pike |
| Lahna | | 0,1 " | Bream |
| Säyne | | 0,2 " | Ide |
| Ahven | 0,8 " | 13,5 " | Perch |
| Made | 0,3 " | 2,3 " | Burbot |
| Yhteensä | 188,0 t /a | 24,1 t /a | Total |




The most important **fish harvests** of the sea off Kuivaniemi in 1980. (Verbal comm. 15.8.1982 RKTL). The harvests came from the statistical square below.

LAPPLAX OY:N JA PERÄMEREN LOHI OY:N VELVOITETARKKAILUTULOKSET VUOSILTA 1978 - 82.
Results of the mandatory monitoring of Lapplax Ltd. and Perameren Lohi Ltd. in 1978-82,

| Pvm Date | Havainto-paikka 1) | Syvyys m 2) | t °C | $O_2$ mg/l | $O_2$ % kyll. 3) | Sameus FTU 4) | Kiintoaine mg/l 5) | Y25 m S/m | Alkalitetti mval/l 6) | pH | Väri mg Pt/l 7) | $COD_{Mn}$ mg/l $O_2$ | BHT7 mg/l | Kok. N µg N/l 8) | $NH_4$-N µg N/l | Kok. P µg P/l 9) | Perustuotanto-kyky mg C/m3d 10) | Pimeäsitoutumi-nen mg C/m³/d 11) | Fek. strept. kpl/100 ml 12) | a-klorofylli µg/l 13) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1978 | | | | | | | | | | | | | | | | | | | | |
| 4.9. | P 1 | 1.0 | 13.3 | 10.4 | 99 | | 3.6 | 439 | 0.66 | 7.7 | 18 | 5.1 | | 319 | | 13 | 148.8 | 19.7 | 0 | |
| | | 3.0 | 13.1 | 10.4 | 99 | | 0.4 | 441 | | 7.7 | 16 | 5.2 | | 309 | | 13 | | | | |
| | P 2 | 1.0 | 13.3 | 10.1 | 97 | | 1.4 | 448 | 0.69 | 7.7 | 18 | 5.1 | | 278 | | 11 | 25.9 | 3.5 | 8 | |
| | | 4.0 | 13.1 | 10.4 | 99 | | 1.4 | 471 | | 7.8 | 16 | 4.9 | | 247 | | 7 | | | | |
| | P 3 | 1.0 | 13.6 | 10.5 | 101 | | 1.4 | 417 | 0,65 | 7.7 | 24 | 5.5 | | 288 | | 3 | 28.9 | 4.3 | 26 | |
| | | 4.0 | 13.2 | 10.3 | 98 | | 1.4 | 460 | | 7.7 | 17 | 5.1 | | 268 | | 7 | | | | |
| 5.10. | P 1 | 1.0 | 5.9 | 15.4 | 123 | 3.5 | 4.2 | 481 | 0.64 | 7.6 | 23 | 5.2 | | 301 | | 14 | 90.2 | 7.3 | 10 | |
| | | 2.0 | 5.7 | 13.4 | 107 | 4.2 | 4.0 | 479 | 0.64 | 7.6 | 23 | 5.2 | | 331 | | 14 | | | | |
| | P 2 | 1.0 | 5.7 | 12.9 | 103 | 2.3 | 2.8 | 479 | 0.66 | 7.6 | 23 | 5.0 | | 278 | | 14 | 45.9 | 3.0 | 96 | |
| | | 5.5 | 5.7 | 12.8 | 102 | 4.2 | 4.2 | 479 | 0.66 | 7.6 | 23 | 4.8 | | 301 | | 13 | | | | |
| | P 3 | 1.0 | 5.7 | 12.5 | 100 | 3.3 | 2.6 | 478 | 0.64 | 7.6 | 13 | 4.8 | | 272 | | 15 | 35.5 | 2.7 | 62 | |
| | | 6.0 | 5.7 | 12.4 | 99 | 3.5 | 4.2 | 479 | 0.66 | 7.6 | 13 | 4.9 | | 257 | | 12 | | | | |
| 1979 | | | | | | | | | | | | | | | | | | | | |
| 11.7. | P 1 | 1.0 | 17.7 | 8.0 | 84 | 4.4 | 1.4 | 228 | 0.39 | 7.5 | 47 | 7.3 | 0.43 | 444 | | 14 | 89.9 | 3.6 | 16 | |
| | | 5.0 | 17.0 | 6.6 | 68 | 3.3 | 0.8 | 252 | | 7.4 | 41 | 6.5 | 0.29 | 895 | | 11 | | | | |
| | P 2 | 1.0 | 17.6 | 7.5 | 79 | 3.1 | 1.4 | 234 | 0.40 | 7.5 | 47 | 7.0 | 0.37 | 402 | | 12 | 101.6 | 2.1 | 0 | |
| | | 5.0 | 15.9 | 7.7 | 78 | 3.3 | 0.8 | 252 | | 7.4 | 40 | 6.4 | 0.27 | 316 | | 12 | | | | |
| | P 3 | 1.0 | 17.3 | 6.8 | 71 | 2.5 | 1.0 | 260 | 0.40 | 7.5 | 43 | 6.5 | 0.24 | 375 | | 13 | 45.1 | 8.3 | 0 | |
| | | 6.0 | 15.8 | 7.0 | 71 | 3.1 | 1.2 | 273 | | 7.4 | 41 | 6.4 | 0.22 | 356 | | 10 | | | | |
| 2.10. | P 1 | 1.0 | 7.0 | 11.0 | 91 | 2.8 | 1.6 | 287 | 0.45 | 7.3 | 43 | 6.6 | | 354 | | 36 | 122.0 | 3.7 | 2 | |
| | | 5.0 | 7.0 | 11.0 | 91 | 3.1 | 1.6 | 297 | | 7.4 | 39 | 6.5 | | 324 | | 24 | | | | |
| | P 2 | 1.0 | 7.1 | 11.0 | 91 | 3.3 | 1.6 | 269 | 0.46 | 7.4 | 52 | 7.0 | | 384 | | 15 | 125.2 | 2.4 | 2 | |
| | | 5.0 | 7.3 | 11.0 | 91 | 2.8 | 2.0 | 278 | | 7.4 | 44 | 6.8 | | 362 | | 14 | | | | |
| | P 3 | 1.0 | 6.8 | 11.1 | 91 | 3.3 | 2.4 | 249 | 0.44 | 7.3 | 61 | 7.4 | | 388 | | 15 | 120.2 | 2.1 | 4 | |
| | | 6.0 | 7.3 | 10.9 | 91 | 2.8 | 1.8 | 288 | | 7.4 | 44 | 7.0 | | 297 | | 12 | | | | |
| 1980 | | | | | | | | | | | | | | | | | | | | |
| 24.6. | P 1 | 1.0 | 18.7 | 8.5 | 91 | 4.7 | 2.6 | 253 | 0.40 | 7.2 | 42 | 7.3 | | 445 | | 26 | 307.9 | 8.3 | 92 | |
| | | 4.0 | 17.7 | 8.8 | 92 | 3.6 | 2.6 | 266 | | 7.4 | 43 | 7.3 | | 439 | | 15 | | | | |
| | P 2 | 1.0 | 18.9 | 8.7 | 94 | 3.6 | 2.0 | 253 | 0.38 | 7.4 | 44 | 7.3 | | 344 | | 20 | 239.4 | 5.4 | 28 | |
| | | 5.0 | 17.6 | 8.7 | 91 | 3.1 | 1.8 | 261 | | 7.4 | 43 | 6.8 | | 343 | | 12 | | | | |
| | P 3 | 1.0 | 19.0 | 8.9 | 98 | 3.9 | 1.4 | 238 | 0.38 | 7.5 | 48 | 7.4 | | 289 | | 14 | 276.0 | 4.6 | 26 | |
| | | 5.0 | 17.8 | 8.9 | 94 | 3.6 | 1.4 | 259 | | 7.4 | 40 | 7.1 | | 252 | | 10 | | | | |
| 10.9. | P 1 | 1.0 | 12.0 | 9.6 | 89 | 5.3 | 6.6 | 506 | | 7.5 | 27 | 5.1 | | 359 | | 24 | | | 136 | |
| | | 6.0 | 12.0 | 9.6 | 89 | 6.1 | 8.0 | 505 | | 7.6 | 27 | 5.0 | | 341 | | 29 | | | | |
| | P 2 | 1.0 | 12.0 | 9.4 | 87 | 3.9 | 5.5 | 499 | | 7.6 | 23 | 4.9 | | 341 | | 27 | | | 58 | |
| | | 5.0 | 12.0 | 9.6 | 89 | 6.4 | 13.0 | 502 | | 7.6 | 30 | 5.3 | | 376 | | 41 | | | | |
| | P 3 | 1.0 | 12.0 | 9.6 | 89 | 5.3 | 6.4 | 503 | | 7.7 | 26 | 5.0 | | 324 | | 29 | | | 80 | |
| | | 4.0 | 12.0 | 10.3 | 96 | 5.3 | 7.4 | 502 | | 7.7 | 26 | 5.1 | | 324 | | 31 | | | | |
| 1981 | | | | | | | | | | | | | | | | | | | | |
| 16.7. | P 1 | 1.0 | 16.3 | 8.7 | 89 | 3.3 | 2.6 | 164 | 0.25 | 7.2 | 114 | 13.0 | | 461 | | 17 | 88.9 | 1.8 | 4 | |
| | | 4.0 | 16.0 | 8.6 | 87 | 2.0 | 2.0 | 215 | | 7.3 | 81 | 10.7 | | 372 | | 10 | | | | |
| | P 2 | 1.0 | 16.3 | 8.5 | 87 | 4.3 | 4.4 | 96,2 | 9.21 | 6.7 | 173 | 23.4 | | 578 | | 36 | 95.2 | 1.4 | 126 | |
| | | 5.0 | 16.1 | 8.7 | 88 | 1.9 | 2.2 | 256 | | 7.0 | 84 | 12.6 | | 394 | | 36 | | | | |
| | P 3 | 1.0 | 16.5 | 8.4 | 86 | 4.3 | 4.2 | 93.0 | 0.21 | 6.7 | 178 | 23.4 | | 595 | | 33 | 102 | 1.9 | 96 | |
| | | 5.0 | 15.6 | 8.6 | 87 | 2.1 | 1.4 | 251 | | 7.1 | 77 | 12.0 | | 259 | | 27 | | | | |
| | P 4 | 1.0 | 16.5 | 8.6 | 87 | 5.4 | 5.2 | 110 | 0.22 | 6.8 | 161 | 21.4 | | 543 | | 29 | 65,6 | 1.7 | 120 | |
| | | 6.0 | 15.8 | 8.4 | 85 | 1.6 | 2.3 | 238 | | 7.0 | 76 | 12.3 | | 350 | | 23 | | | | |
| | P 5 | 1.0 | 16.3 | 9.0 | 92 | 1.8 | 3.0 | 164 | 0.27 | 7.2 | 113 | 13.6 | | 420 | | 52 | 77.2 | 1.3 | 84 | |
| | | 2.8 | 16.0 | 8.9 | 90 | 1.5 | 1.6 | 199 | | 7.2 | 93 | 12.0 | | 394 | | 43 | | | | |
| | P 6 | 1.0 | 16.3 | 9.0 | 92 | 3.1 | 2.0 | 170 | 0.26 | 7.2 | 109 | 13.6 | | 420 | | 18 | 40.6 | 1.3 | 136 | |
| | | 3.5 | 16.0 | 8.6 | 87 | 3.4 | 2.4 | 211 | | 7.3 | 85 | 12.3 | | 367 | | 12 | | | | |
| 26.8. | P 1 | 1.0 | 13.7 | 9.3 | 90 | 1.3 | 1.1 | 322 | 0.47 | 7.5 | 132 | 11.2 | | 553 | | 15 | 151 | 5.2 | 22 | |
| | | 6.0 | 13.4 | 9.2 | 88 | 1.3 | 3.9 | 346 | | 7.5 | 114 | 10.6 | | 405 | | 20 | | | | |
| | P 2 | 1.0 | 13.8 | 9.5 | 92 | 1.3 | 0.3 | 348 | 0.50 | 7.5 | 108 | 9.8 | | 405 | | 28 | 34.8 | 1.2 | 0 | |
| | | 6.0 | 13.7 | 9.4 | 91 | 1.1 | 4.6 | 347 | | 7.6 | 106 | 10.1 | | 396 | | 13 | | | | |
| | P 3 | 1.0 | 13.6 | 9.5 | 92 | 1.3 | 2.9 | 333 | 0.47 | 7.6 | 126 | 11.0 | | 387 | | 23 | 86.4 | 1.6 | 0 | |
| | | 5.0 | 13.6 | 9.3 | 90 | 1.1 | 3.1 | 323 | | 7.6 | 120 | 10.7 | | 387 | | 10 | | | | |
| | P 4 | 1.0 | 13.5 | 9.4 | 90 | 1.3 | 2.6 | 334 | 0.47 | 7.5 | 121 | 10.9 | | 442 | | 29 | 83.6 | 2,0 | 0 | |
| | | 6.0 | 13.5 | 9.4 | 90 | 1.1 | 0.9 | 333 | | 7.6 | 81 | 9.0 | | 359 | | 21 | | | | |
| 15.9. | P 1 | 1.0 | 9.5 | 10.3 | 90 | 1.3 | 2.8 | 359 | 0.50 | 7.4 | 100 | 10.6 | | 425 | | 13 | 182 | 4.0 | 2 | |
| | | 5.0 | 10.0 | 10.1 | 90 | 1.1 | 3.6 | 423 | | 7.4 | 63 | 9.4 | | 393 | | 12 | | | | |
| | P 2 | 1.0 | 9.1 | 10.2 | 89 | 1.6 | 3.8 | 328 | 0.47 | 7.4 | 139 | 12.2 | | 474 | | 15 | 108 | 2.8 | 6 | |
| | | 3.5 | 9.4 | 10.3 | 90 | 1.9 | 1.8 | 344 | | 7.4 | 118 | 7.8 | | 474 | | 13 | | | | |
| | P 3 | 1.0 | 9.5 | 10.4 | 91 | 1.9 | 1.8 | 337 | 0.46 | 7.4 | 130 | 11.8 | | 583 | | 14 | 132 | 4.0 | 8 | |
| | | 4.0 | 9.5 | 10.3 | 90 | 1.4 | 3.0 | 339 | | 7.4 | 119 | 11.7 | | 556 | | 12 | | | | |
| | P 4 | 1.0 | 9.5 | 10.3 | 90 | 1.3 | 2.8 | 350 | 0.48 | 7.4 | 116 | 11.1 | | 574 | | 13 | 121 | 4,0 | 14 | |
| | | 5.0 | 10.0 | 10.3 | 91 | 1.3 | 2.4 | 387 | | 7.4 | 77 | 9.1 | | 547 | | 16 | | | | |

1) Observation location. 2) Depth. 3) Saturation. 4) Turbidity. 5) Solid matter.
6) Alkalinity. 7) Colour. 8) Total N. 9) Total P. 10) Primary productivity.
11) Carbon fixation in the dark. 12) Fecal streptococci. 13) Chrophyll a.

**LIITE 2/2**
Appendix 2/2

| Pvm Date | Havaintopaikka 1) | Syvyys m 2) | t °C | $O_2$ mg/l | $O_2$ % kyll. 3) | Sameus FTU 4) | Kiintoaine mg/l 5) | $\gamma_{25}$ mS/m | Alkaliteetti mval/l 6) | pH | Väri mg Pt/l 7) | $COD_{Mn}$ mg/l $O_2$ | BHT$_7$ mg/l | Kok. N µg N/l 8) | $NH_4$-N µg N/l | Kok. P µg P/l 9) | Perustuotantokyky mg C/m3d 10) | Pimeäitoutuminen mg C/m3/d 11) | Fek. strept. kpl/100 ml 12) | a-klorofylli µg/l 13) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1982 | | | | | | | | | | | | | | | | | | | | |
| 23.4. | P 1 | 1.0 | 0.0 | 10.3 | 70 | 1.9 | 0.9 | 60.4 | | 6.4 | 73 | 9.1 | | 764 | | 18 | | | 0 | |
| | | 5.5 | 1.2 | 10.3 | 73 | 0.6 | 0.6 | 530 | | 7.0 | 27 | 5.2 | | 470 | | 11 | | | | |
| | P 2 | 1.0 | 0.1 | 12.1 | 83 | 5.6 | 4.6 | 15.0 | | 6.8 | 232 | 15.5 | | 893 | | 56 | | | 2 | |
| | | 5.0 | 1.2 | 10.0 | 71 | 0.9 | 0.6 | 506 | | 7.0 | 33 | 5.7 | | 378 | | 10 | | | | |
| | P 3 | 1.0 | 0.0 | 12.0 | 82 | 5.9 | 2.4 | 9.9 | | 6.9 | 227 | 15.8 | | 884 | | 55 | | | 4 | |
| | | 6.0 | 1.5 | 8.9 | 63 | 0.6 | 0.6 | 534 | | 6.9 | 27 | 5.6 | | 309 | | 13 | | | | |
| | P 4 | 1.0 | 0.1 | 10.1 | 69 | 1.4 | 0.6 | 10.6 | | 6.5 | 73 | 9.1 | | 488 | | 16 | | | 0 | |
| | | 4.0 | 0.5 | 10.7 | 74 | 1.2 | 0.9 | 383 | | 6.8 | 49 | 7.5 | | 442 | | 14 | | | | |
| | P 5 | 1.0 | 0.1 | 12.5 | 86 | 5.0 | 4.0 | 30.2 | | 6.6 | 152 | 11.7 | | 958 | | 44 | | | 0 | |
| | | 3.0 | 0.7 | 10.0 | 70 | 2.0 | 0.7 | 879 | | 6.8 | 81 | 8.8 | | 571 | | 20 | | | | |
| | P 6 | 1.0 | 0.2 | 11.4 | 78 | 4.9 | 3.1 | 13.2 | | 6.8 | 199 | 14.2 | | 792 | | 50 | | | 0 | |
| | | 4.0 | 1.3 | 9.5 | 67 | 1.1 | 1.0 | 486 | | 6.9 | 35 | 6.6 | | 396 | | 14 | | | | |
| 16.6. | P 1 | 1.0 | 6.3 | 12.0 | 115 | 1.3 | 0.8 | 479 | 0.62 | 7.6 | 44 | 7.1 | | 289 | 30 | 14 | 167 | 6.0 | 0 | 3.2 |
| | | 4.5 | 5.0 | 12.1 | 113 | 1.1 | 1.7 | 500 | | 7.5 | 37 | 7.0 | | 289 | 2 | 16 | | | | |
| | P 2 | 1.0 | 7.3 | 11.7 | 111 | 1.5 | 3.1 | 423 | 0.60 | 7.5 | 65 | 8.2 | | 332 | 7 | 18 | 270 | 6.7 | 14 | 2.7 |
| | | 4.0 | 5.1 | 12.0 | 112 | 1.1 | 2.1 | 488 | | 3.5 | 40 | 6.9 | | 306 | 12 | 13 | | | | |
| | P 3 | 1.0 | 6.5 | 11.9 | 114 | 1.0 | 1.3 | 464 | 0.61 | 7.6 | 44 | 7.1 | | 302 | 14 | 12 | 165 | 9.8 | 16 | 3.2 |
| | | 5.5 | 6.5 | 11.9 | 114 | 1.1 | 1.0 | 478 | | 7.6 | 43 | 7.1 | | 310 | 5 | 11 | | | | |
| | P 4 | 1.0 | 6.7 | 11.9 | 114 | 1.1 | 2.0 | 467 | 0.62 | 7.6 | 47 | 7.1 | | 310 | 6 | 12 | 152 | 10 | 0 | 3.3 |
| | | 4.0 | 5.8 | 11.9 | 112 | 1.0 | 1.2 | 475 | | 7.6 | 48 | 6.9 | | 310 | 10 | 11 | | | | |
| | P 5 | 1.0 | 6.1 | 12.3 | 117 | 1.1 | 1.1 | 499 | 0.63 | 7.6 | 38 | 6.4 | | 302 | 14 | 13 | 162 | 7.4 | 4 | 3.1 |
| | | 2.5 | 5.5 | 12.2 | 115 | 1.0 | 1.3 | 500 | | 7.6 | 35 | 7.0 | | 310 | 6 | 18 | | | | |
| | P 6 | 1.0 | 6.5 | 12.1 | 115 | 1.1 | 1.0 | 472 | 0.62 | 7.6 | 41 | 7.1 | | 283 | 17 | 12 | 226 | 3.5 | 2 | 4.4 |
| | | 3.0 | 6.5 | 12.0 | 115 | 1.1 | 1.3 | 494 | | 7.6 | 41 | 7.1 | | 328 | 19 | 15 | | | | |
| 9.7. | P 1 | 1.0 | 18.2 | 9.7 | 102 | 1.4 | 0.1 | 356 | 0.52 | 7.6 | 47 | 7.4 | | 316 | 8 | 17 | 126 | 4.5 | 2 | 3.3 |
| | | 3.4 | 17.9 | 9.0 | 95 | 1.2 | 1.4 | 365 | | 7.6 | 46 | 7.7 | | 307 | 17 | 13 | | | | |
| | P 2 | 1.0 | 19.4 | 9.3 | 97 | 1.4 | 0.8 | 336 | 0.49 | 7.5 | 50 | 7.9 | | 345 | 14 | 16 | 90 | 4.6 | 6 | 3.2 |
| | | 3.5 | 17.5 | 9.2 | 96 | 1.4 | 0.7 | 355 | | 7.6 | 48 | 8,0 | | 336 | 7 | 17 | | | | |
| | P 3 | 1.0 | 17.9 | 9.7 | 102 | 1.2 | 1.7 | 352 | 0.50 | 7.5 | 49 | 7.9 | | 288 | 25 | 9 | 169 | 4.1 | 6 | 3.0 |
| | | 5.0 | 17.3 | 9.2 | 96 | 1.6 | 1.4 | 374 | | 7.5 | 46 | 7.8 | | 268 | 13 | 9 | | | | |
| | P 4 | 1.0 | 18.0 | 9.7 | 103 | 1.3 | 1.4 | 375 | 0.53 | 7.6 | 42 | 7.8 | | 259 | 35 | 7 | 118 | 4.9 | 0 | 2.8 |
| | | 3.5 | 17.9 | 9.8 | 103 | 0.88 | 1.1 | 382 | | 7.6 | | 8,0 | | 259 | 15 | 8 | | | | |
| 18.8. | P 1 | 1.0 | 16.7 | 9.4 | 98 | 1.0 | 2,1 | 328 | 0.49 | 7.9 | 33 | 6.8 | | 416 | 26 | 10 | 121 | 3,2 | 10 | 4.3 |
| | | 4.0 | 16.1 | 9.1 | 93 | 0.81 | 1.3 | 331 | | 7.7 | 33 | 6.8 | | 435 | 37 | 13 | | | | |
| | P 2 | 1.0 | 16.7 | 9.2 | 96 | 1.1 | 0.6 | 322 | 0.49 | 7.8 | 35 | 7.0 | | 411 | 45 | 9 | 114 | 3.5 | 4 | 3.4 |
| | | 3.5 | 16.3 | 9.1 | 94 | 0.94 | 0.3 | 328 | | 7.8 | 33 | 7.1 | | 383 | 47 | 21 | | | | |
| | P 3 | 1.0 | 17.0 | 9.2 | 96 | 0.56 | 0.1 | 339 | 0.49 | 7.7 | 31 | 7.0 | | 378 | 15 | 15 | 76 | 2.9 | 2 | 3.0 |
| | | 2.5 | 16.2 | 9.3 | 96 | 0.81 | 0.4 | 344 | | 7.8 | 30 | 6.6 | | 359 | 11 | 9 | | | | |
| | P 4 | 1.0 | 16.7 | 9.4 | 98 | 0.56 | 0.6 | 347 | 0.48 | 7.8 | 29 | 6.5 | | 350 | 11 | 10 | 90 | 5.4 | 0 | 3,2 |
| | | 3.5 | 16.3 | 9.3 | 96 | 0.50 | 0.3 | 340 | | 7.8 | 30 | 6.8 | | 359 | 12 | 11 | | | | |
| | P 5 | 1.0 | 17.0 | 8.5 | 89 | 1.2 | 2.8 | 322 | 0.50 | 7.6 | 37 | 7.0 | | 625 | | 29 | 95 | 4.2 | 50 | 5.1 |
| | P 6 | 1.0 | 16.6 | 9.2 | 95 | 1.1 | 1.1 | 330 | 0.50 | 7.7 | 35 | 6,8 | | 523 | | 15 | 160 | 4,6 | 34 | 4.6 |
| | | 4.0 | 16.2 | 8.9 | 82 | 0.88 | 1.3 | 334 | | 7.7 | 33 | 7.0 | | 411 | | 11 | | | | |
| 30.9. | P 1 | 1.0 | 8.5 | | | 2.4 | 2.4 | 322 | 0.46 | 5.9 | 45 | 8.3 | | 340 | 31 | 16 | 261 | 6.5 | 2 | 9.2 |
| | | 5.0 | 8.9 | 10.6 | 93 | 1.9 | 2.8 | 376 | | 7,4 | 37 | 7,3 | | 292 | 19 | 15 | | | | |
| | P 2 | 1.0 | 8.6 | 10.8 | 94 | 2.3 | 1.8 | 325 | 0.46 | 7,4 | 47 | 8.1 | | 311 | 18 | 15 | 359 | 3.8 | 0 | 8.9 |
| | | 4.0 | 8.8 | 10.7 | 93 | 1.8 | 2.1 | 361 | | 7.4 | 37 | 7,6 | | 292 | 16 | 14 | | | | |
| | P 3 | 1.0 | 8.6 | 10.8 | 94 | 1.6 | 2.7 | 307 | 0.46 | 7.4 | 51 | 8.5 | | 331 | 13 | 18 | 426 | 3.8 | 10 | 8.8 |
| | | 4.5 | 9.0 | 10.5 | 92 | 1.5 | 1.4 | 373 | | 7.5 | 35 | 7.3 | | 282 | 14 | 13 | | | | |
| | P 4 | 1.0 | 8.8 | 10.8 | 94 | 1.9 | 1.7 | 362 | 0.50 | 7,8 | 32 | 7.7 | | 340 | 29 | 15 | 471 | 1.8 | 0 | 10 |
| | | 5.5 | 9.1 | 10.8 | 95 | 1.3 | 1.5 | 416 | | 7.5 | 32 | 7,3 | | 310 | 9 | 13 | | | | |

1) Observation location. 2) Depth. 3) Saturation. 4) Turbidity.
5) Solid matter. 6) Alkalinity. 7) Colour. 8) Total N. 9) Total P.
10) Primary productivity. 11) Carbon fixation in the dark.
12) Fecal streptococci. 13) Chrophyll a.

location code

date time

| Pistekoodi | 15.6. klo 15.00–16.6. klo 17.00 | | | 8.7. klo 17.00–9.7. klo 17.00 | | | 29.7. klo 13.00 30.7. klo 14.00 | | 16.8. klo 12.00 18.8. klo 18.00 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | a) Alkupaino[1] mg | b) Painonlisäys mg/havas-m² | c) Klorofylli-a µg/havas-m² | a) Alkupaino mg | b) Painonlisäys mg/havas-m² | c) Klorofylli-a µg/havas-m² | a) Alkupaino mg | b) Painonlisäys mg/havas-m² | a) Alkupaino mg | b) Painonlisäys mg/havas-m² | d) Kiintoaine mg/havas-m² | c) Klorofylli-a µg/havas-m² |
| 1 | 649,4 | 1217,2 | 2439,1 | 623,4<br>601,7 | 154,0 | 101,1 | 582,2 | 332,0 | 650,8<br>648,2 | 572,0 | 542 | 2172 |
| 2 | 649,4 | 449,6 | 1569,0 | 618,2<br>667,8 | 64,0 | 192,3 | 586,8 | 724,4 | 637,4<br>636,1 | 1180,0 | 1052 | 5824 |
| 3 | 649,4 | 399,3 | 1111,8 | 608,1<br>706,5 | 40,8 | 93,3 | 564,0 | 100,8 | 642,6<br>655,5 | 308,8 | 184 | 648 |
| 4 | 649,4 | 275,6 | 363,7 | 590,6<br>610,8 | 108,4 | 44,0 | 608,4 | 78,8 | 643,2<br>640,9 | 173,6 | 124 | 408 |

1) Alkupaino ilmoitettu havaston keskipainona Starting weight given as the average weight of netting

| Pistekoodi | 6.9. klo 10.00 7.9. klo 12.00 | | | | 30.9. klo 10.00 1.10. klo 10.00 | | | |
|---|---|---|---|---|---|---|---|---|
| | a) Alkupaino mg | b) Painonlisäys mg/havas-m² | d) Kiintoaine mg/havas-m² | c) Klorofylli-a µg/havas-m² | a) Alkupaino mg | b) Painonlisäys mg/havas-m² | d) Kiintoaine mg/havas-m² | c) Klorofylli-a µg/havas-m² |
| 1 | 642,4<br>645,0 | 31,6 | 44 | 736 | 628,5<br>631,3 | 0,0 | 11,6 | 7,6 |
| 2 | 648,0<br>642,2 | 149,2 | 132 | 136 | 632,8<br>620,2 | 0,0 | 7,2 | 12,0 |
| 3 | 644,7<br>645,5 | 28,4 | 44 | 224 | 617,6<br>631,2 | 0,0 | 0,0 | 9,2 |
| 4 | 643,2<br>648,3 | 15,2 | 19,2 | 92 | 616,5<br>613,1 | 0,0 | 2,8 | 9,2 |

a) Starting weight
b) Weight increment, mg/netting $m^2$
c) Chrophyll a, µg/netting $m^2$
d) Solid matter, mg/netting $m^2$

Major fishing grounds off Kuivaniemi

**KUIVANIEMEN EDUSTAN KALASTUKSEN TÄRKEIMMÄT PYYNTIPAIKAT**

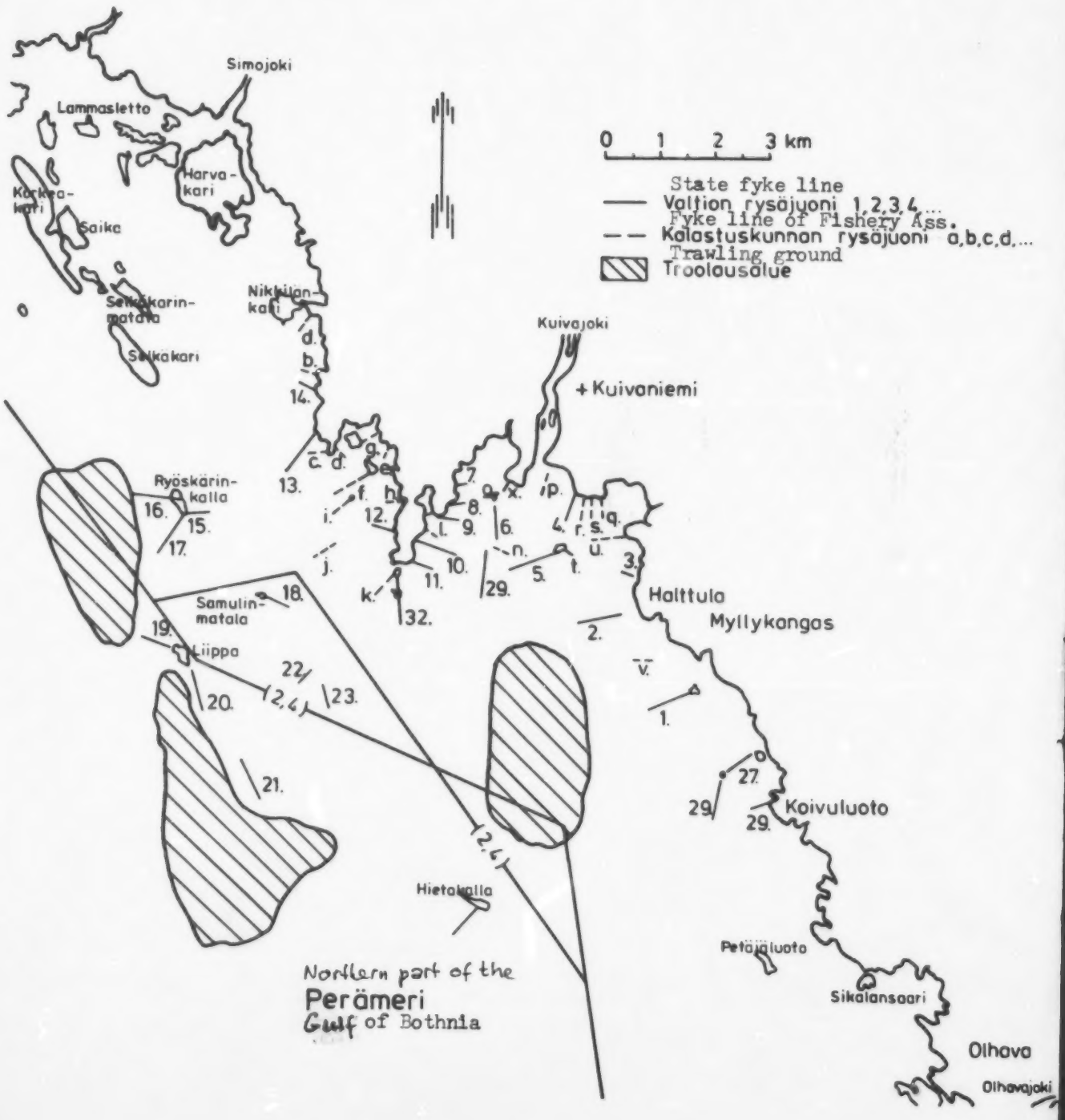
Fishing locations off Kuivaniemi owned by the state.
**Valtion omistamat kalastuspaikat Kuivaniemen edustalla**
(The numbers refer to the map in Appendix 4/3)
**(Numerot viittaavat liitteen 4/3 karttaan)**

| | | length of fyke line<br>juonen pituus |
|---|---|---|
| 1. | Onsaja | 823 m |
| 2. | Kaakkuri | 823 m |
| 3. | Oriniemi | 165 m |
| 4. | Hietajuoni | 384 m |
| 5. | Halttulanmatala | 823 m |
| 6. | Lahdenmatala | 366 m |
| 7. | Ankkurikari | 137 m |
| 8. | Lahdenranta | 329 m |
| 9. | Käpsänranta | 293 m |
| 10. | Häskeri | 732 m |
| 11. | Rahtunen | 329 m |
| 12. | Kokko | 329 m |
| 13. | Nikka | 823 m |
| 14. | Raumanperä | 329 m |
| 15. | Kallan mp. eteläpää south end | 823 m |
| 16. | Kallankarvo | 823 m |
| 17. | Kallanletto | 823 m |
| 18. | Samuli (2 juonta) (2 lines) | 640 m |
| 19. | Liippa luodep. NW side | 549 m |
| 20. | Liippa eteläp. S side | 823 m |
| 21. | Liipan ulkomatala seaward shallow | 823 m |
| 22. | Rintamatala keskikari middle area | |
| 23. | Rintamatala eteläpuoli S side | |
| 24. | Aaponmatala | |
| - | Krassi | |
| 26. | Jussinmatala | |
| 27. | Kokonsalmi | 549 m |
| 28. | Koivuluoto and ja Henkikallio | 823 m ja 165 m |
| 29. | Käpsänkallio | 823 m |
| - | Aallonmatala | |
| 31. | Hietakalla | |
| 32. | Kuivamatala | 823 m |
| - | Krassi luodepää NW end | |

Fishing locations rented by the Kuivaniemi Fishery Association
Kuivaniemen kalastuskunnan vuokraamia kalastuspaikkoja
(The letters refer to the map in Appendix 4/3)
(Kirjaimet viittaavat liitteen 4/3 karttaan)

| | | length of fyke line / juonen pituus |
|---|---|---|
| a. | Tuonsuulahti | 300 m |
| b. | Kaupinniemi | 300 m |
| c. | Nikan länsipuoli W side | 300 m |
| d. | Nikan itäpuoli E side | 150 m |
| e. | Kotalahden perä | 150 m |
| f. | Isoletto | 500 m |
| g. | Pikkuletto | 180 m |
| h. | Saunaranta | 150 m |
| i. | Nierinletto | 300 m |
| j. | Antinmatala | 500 m |
| k. | Kuivamatala | 500 m |
| l. | Maalikivi | 180 m |
| m. | Haminan perä | 80 m |
| n. | Pikkukallio | 300 m |
| o. | Lahdenmatala | 80 m |
| p. | Pankinjuoni | 300 m |
| q. | Plassinnokka | 200 m |
| r. | Karinletto | 300 m |
| s. | Petokari | 150 m |
| t. | Halttulanmatala | 80 m |
| u. | Röyttänranta | 500 m |
| v. | Halttulan valkama port | 300 m |
| x. | Kyytikarinnokka | 180 m |

LIITE 4/3


Simojoki
Lammasletto
Harva-
kari
Karkea-
kari
Saikc
Selkäkarin-
matala
Selkakari
Nikkilän-
kari
Kuivajoki
+ Kuivaniemi
Ryöskärin-
kalla
Samulin-
matala
Liippa
Halttula
Myllykangas
Koivuluoto
Hietakalla
Petäjäluoto
Sikalansaari
Olhava
Olhavajoki
0 1 2 3 km
State fyke line
Valtion rysäjuoni 1,2,3,4...
Fyke line of Fishery Ass.
Kalastuskunnan rysäjuoni a,b,c,d,...
Trawling ground
Troolausalue
Northern part of the
Perämeri
Gulf of Bothnia